JOURNAL of the AMERICAN WELDING SOCIETY

VOLUME 13
NUMBER 6

JUNE
1934

Published Monthly

FOR THE ADVANCEMENT OF THE SCIENCE AND ART OF WELDING

WELDS TO STAND AN EARTHQUAKE . .

For only a few cents more

IN A 250-mile system of underground piping, welds made with Oxweld No. 1 High Test Steel Welding Rod withstood the terrific shock of a series of earthquakes recently experienced on the West Coast. Piping services generally were disrupted, but *not a single joint welded with this welding rod failed.*

Fortunately few welds are actually tried by earthquake. But, every day most welds are subject to the vibration, wide range of temperature, strain and shock encountered in service. Oxweld No. 1 High Test Steel Welding Rod was developed to meet such conditions and provide an over-all factor of safety adequate to assure welds of the highest quality.

With this rod even the welder with limited experience can increase the average tensile strength of his welds 11,000 lb. per sq. in. Try it—the few cents difference in cost represents only a fractional percentage of the cost of the finished job.

Oxweld No. 1 High Test Steel Welding Rod has made new records in strength, dependability, speed and economy.

●

Strength—Oxweld No. 1 High Test Steel Welding Rod makes welds 20 per cent stronger than mild steel. The *average* weld made with Oxweld No. 1 High Test Steel Welding Rod is equivalent in strength and soundness to an *exceptional* weld with ordinary rod.

Uniformity—Careful testing of every lot eliminates all rod which does not conform to rigid specifications. The uniform performance of Oxweld No. 1 High Test Steel Welding Rod is further assured by welding tests to which it is submitted during manufacture.

Speed—Oxweld No. 1 High Test Steel Welding Rod is self-fluxing and deoxidizing. Proper fusion is more easily obtained, permitting an average of 20 per cent increase in welding speed and a corresponding decrease in gas consumption.

Economy—Because it is time-saving, Oxweld No. 1 High Test Steel Welding Rod cuts costs and reduces gas consumption to a minimum. Its economy in avoiding rejects or possible failures in service is inestimable.

●

When ordering be sure to use the full name—Oxweld No. 1 High Test Steel Welding Rod.

SEND FOR THIS VALUABLE WELDING ROD BOOK

It lists the properties, characteristics and uses of each Oxweld welding rod. It contains reliable welding rod information in a form convenient for quick reference. Get your copy today. Write the nearest Linde District Office.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

126 Producing Plants — 627 Warehouse Stocks

IN CANADA, DOMINION OXYGEN COMPANY, LTD., TORONTO

Sales Offices:

Atlanta	Dallas	Memphis	Portland, Ore.
Baltimore	Denver	Milwaukee	St. Louis
Birmingham	Detroit	Minneapolis	Salt Lake City
Boston	El Paso	New Orleans	San Francisco
Buffalo	Houston	New York	Seattle
Butte	Indianapolis	Philadelphia	Spokane
Chicago	Kansas City	Phoenix	Tulsa
Cleveland	Los Angeles	Pittsburgh	

LINDE OXYGEN • PREST-O-LITE ACETYLENE • OXWELD APPARATUS AND SUPPLIES • UNION CARBIDE

JOURNAL of the AMERICAN WELDING SOCIETY

Issued Monthly

Vol. 13
No. 6

JUNE
1934

WM. SPRARAGEN
Editor

AMERICAN WELDING SOCIETY

PUBLICATION OFFICE
20th and Northampton Sts.
Easton, Pa.

EDITORIAL AND GENERAL OFFICES
33 West 39th St.,
New York, N. Y.

OFFICERS FOR 1933–34

President F. P. McKibben
Treasurer C. A. McCune

Senior Vice-President J. J. Crown
Secretary M. M. Kelly

Divisional Vice-Presidents
H. N. Ewertz, New York & New England
D. J. Williams, Pacific Coast
A. F. Davis, Middle Eastern
H. S. Card, Middle Western
G. Raymond, Southern Division

SECTION HEADQUARTERS

PHILADELPHIA
Engineers' Club, 1317 Spruce St.

CHICAGO
608 South Dearborn St.

PITTSBURGH
Room 1201, House Building

NEW YORK
33 West Thirty-Ninth St.

NORTHERN NEW YORK
General Electric Co., Schenectady, N. Y.

CLEVELAND
410 Hanna Building

SAN FRANCISCO
Park Ave. & Hallbeck St., Emeryville, Cal.

LOS ANGELES
P. O. Box 194, Arcade Station

BOSTON
Engineering Societies of Boston, 715 Tremont Temple

WESTERN NEW YORK
500 Morgan Bldg., Buffalo, N. Y.

DETROIT
General Electric Co., 5950 Third Avenue

PORTLAND, ORE.
P. O. Box 1899, Station F

CONTENTS

Technical Papers, Items and Reports

	Page
Applications of Structural Welding in the General Electric Company's Outdoor Mercury-Steam-Electric Power Plant, by H. Malcolm Priest	2
The Effect of Welding Current on the Fatigue Strength of Welds, by Chas. H. Jennings	7
Oxyacetylene Cutting of Structural Steel, by H. H. Moss	8
Soap Manufacturer Chooses Stainless-Clad Steel for Glycerin Bleach Tanks, by William B. Keelor	12
Restoring Battered Rail Ends by Welding, by B. C. Tracey and O. A. Tilton	13
Welding of Structural Nickel Steel, by W. L. Warner	15
Welding Pipe in a Skating Rink, by W. T. Cook	23
An All-Welded Diesel Towboat, by R. B. Reid	23
Test of a Flat Steel-Plate Floor under Loads, by L. B. Tuckerman, A. H. Stang and W. R. Osgood	24
Training Welders, by H. T. Bent	25

Departments

From Abroad	
The Stresses in Fusion Joints, by Prof. E. G. Coker, D.Sc., Miss R. Levi, Ph.D. and R. Russell, B.Sc.	26
Communications	
Discussion of Paper on Electric Arc Welding under Water, by Cyril D. Jensen	31
Mistake in Testing Proves Quality of Weld Metal, by A. F. Davis	31
Current Welding Literature	32

Society and Related Activities

Fall Meeting	33
Tentative Specifications for Steel	33
Metals & Alloys	33
Standards	33
Obituary	33
Membership	33
Membership Certificate	34
Year Book	34
Welding Books	34
United States Civil Service Examination	34
Junior Patent Examiner	34
Section Activities	34

Copyright, 1934, by the American Welding Society.

Subscription $4.00 per year in United States and possessions; $4.50 in Canada; Foreign Countries, $5.50;

Entered as second-class matter January 15, 1932, at the post-office at Easton, Pa., under the Act of March 3, 1879.

The Society is not responsible for any statement made or opinion expressed in its publications. Permission is given to reprint any article after its date of publication, provided proper credit is given.

Applications of Structural Welding in the General Electric Company's Outdoor Mercury-Steam-Electric Power Plant

By H. MALCOLM PRIEST

✦Paper presented at Joint New York Section, American Welding Society with Iron and Steel and Power Divisions, American Society of Mechanical Engineers, by H. M. Priest, Railroad Research Bureau, U. S. Steel Corp.

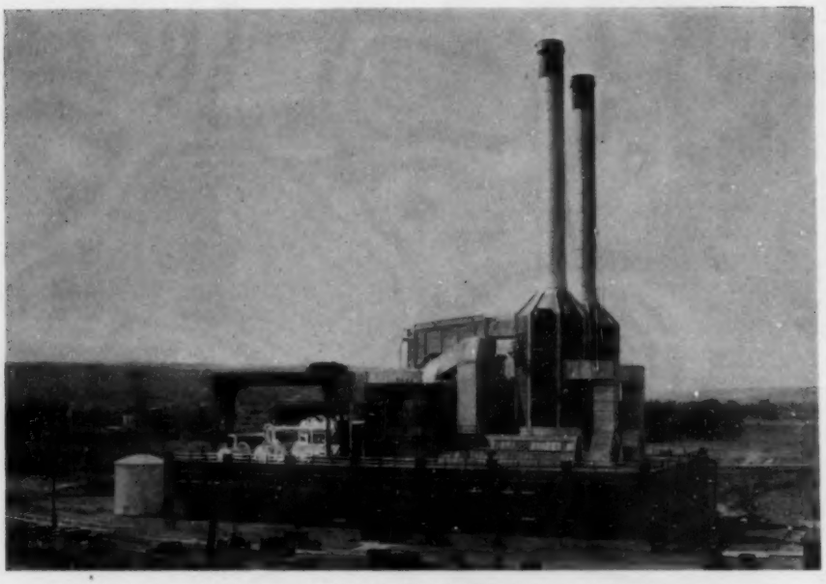


Fig. 1—G. E. Outdoor Mercury-Steam-Electric Power Station. View from Southeast

THE outdoor mercury-steam-electric power station of the General Electric Company at Schenectady, New York, is a noteworthy structure in many respects. All of the structural steel, comprising about 1400 tons, was completely shop and field welded. The structure was designed by the General Electric Company and the welding details were laid out by the American Bridge Company, which fabricated and erected the steel. Because of the unusual character of the building there were many interesting and varied problems connected with the design and fabrication by welding. It is not possible within the limits of this paper to discuss in detail the solutions which were evolved, but only to illustrate briefly the method of handling some of the more important features.

Figure 1 is a view of the completed station. The twin stacks, emerging from the tops of the coal bunkers and rising to a height of about 190 ft. above the ground, stand out prominently. One receives the general impression of *a two-story building with much of the power plant equipment carried on the roof or projecting through it.* Through the sash on the end of the central portion of the building may be seen the steam boiler and beyond is the mercury boiler. To the left is the crane, with a high and low rail, which serves the turbine equipment on the *roof.*

The columns were securely anchored to the concrete foundations, as will be seen in Fig. 2. This is the base of a double column and is built up entirely from plates. (Structural engineers will readily picture the usual type of "boot" construction with top and bottom angles and angle stiffeners.) The bar stiffeners were welded along their vertical edges and also on their top and bottom ends. A bar across the outstanding edges lends stiffness against their tendency to buckle under compressive loads.

The beam framing problems in this structure were difficult because of their size and the heavy reactions to be carried. In many cases they were complicated by having to provide for the connections of the vertical bracing. The sketches in Fig. 3 illustrate the types which were used most generally throughout the building. So far as possible, all end loads were carried on seats, consisting of an angle as in sketch *A* or on a stiffened plate as shown in sketch *B*. A rigid top flange connection was avoided by field welding the toes of the top

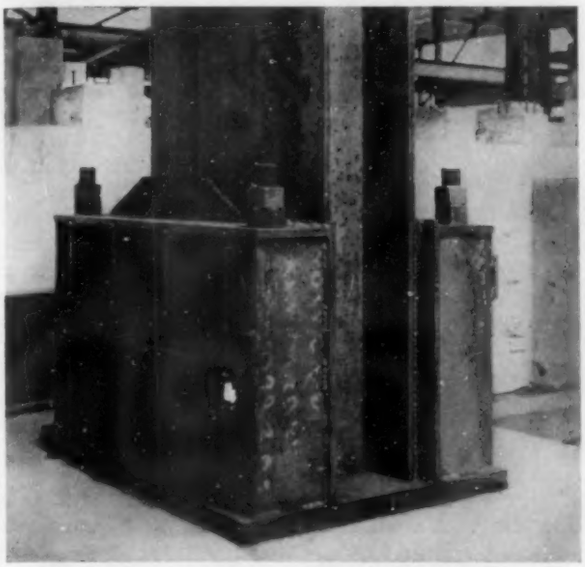


Fig. 2—Arc-Welded Base Column

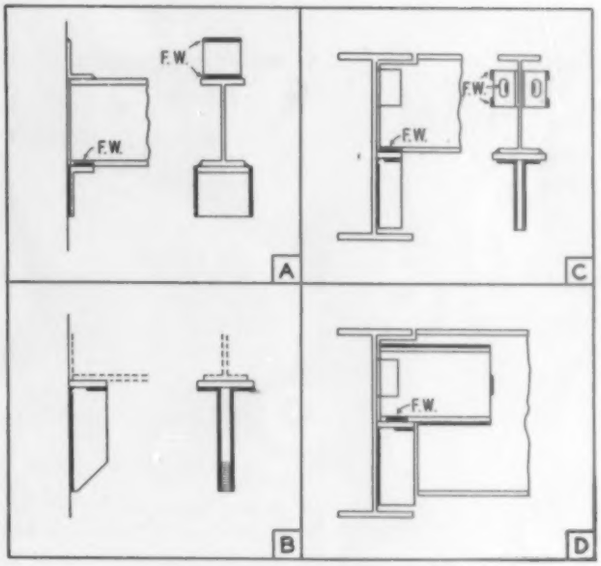


Fig. 3—Beam Framing Details

angle and utilizing the flexibility of the angle to permit motion of the top flange when the beam is under load. The bottom flange of the beam was welded to the outstanding leg of the seat angle in all cases. For beams framing into girder beams, the construction of sketch *C* was followed whenever the difference in depth of the two beams permitted its use. In order to provide lateral support for the web of the framing-in beam and yet leave it free to move under deflection, a slip-joint connection was provided by placing a short angle on either side of the web and welding the angles to the girder beam as indicated in the sketch.

A difficult type of connection to make was that shown in sketch *D*. In many instances the beams to be supported were 30 in. or more in depth with reactions of 60,000 to 80,000 lb. Web-shear connections did not appear to be feasible and seated connections were, therefore, the only alternative. A pair of short lengths of channel was shop welded to either side of the web and served to transmit the load to the seat. Figures 4, 5 and 6 are photographs in which these various types of beam framing may be seen.

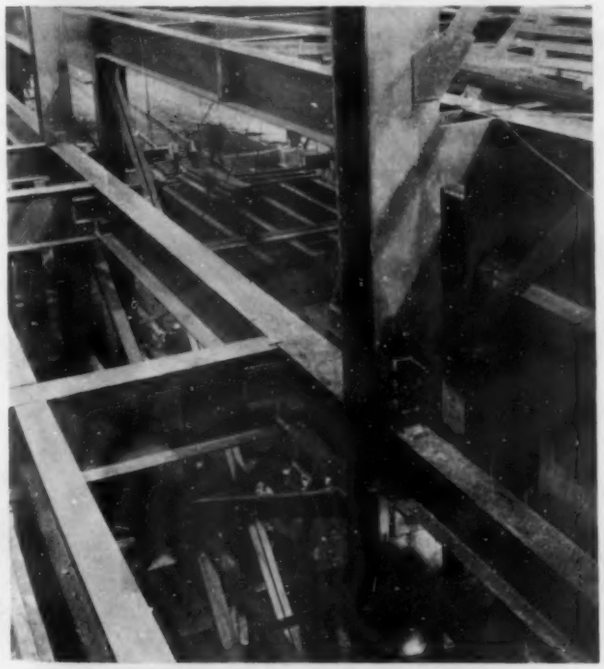


Fig. 4—Framing Details, Crane Column

In Fig. 6 are clearly shown the plate girders supporting the low rail for the travelling crane. The span is 27 ft. 0 in. and each girder is made up of a web plate 50 x 1 in. and two flange plates, 16 x 2 in., welded to the web plate with continuous lines of $^3/_8$-in. welds on either side of the web. The end bearing stiffeners are 7 x $1^1/_2$-in. bars, while the intermediate stiffeners are 7 x $^3/_4$. Intermittent welding attached the stiffeners to the web and their outstanding edges were welded to the flanges. These girders were designed for simply supported ends but, since the top flange had to project through the finished roof in order to carry the crane rail, it became necessary to seal the gap between the abutting ends. This requirement led to butt welding of the entire top flange and splicing the web for the moment at the support, considering the girders as continuous over the columns. The ends were finished to length so that the compression in the bottom flanges was carried directly in bearing. The 175-lb. crane rail was erected and aligned by means of a few temporary hook bolts until the rail clamps were field welded.

Figure 7 is a photograph taken during construction which shows very clearly the crane runway with the plate girders just described. The end bay in the foreground is outside the building and permits the crane to unload a car on the track which is located in this bay. A car may be seen with a piece of equipment ready to be lifted into place.

One of the interesting features of this power station is the two trusses which support the mercury boiler. Figure 8 shows the erection of the first truss. The second one rests on the near end of the plate girder at the left of the photograph and on a similar girder on the right which is concealed by the intervening columns.

In Fig. 9 are given the stresses and sizes of the principal members of the truss. The span is 45 ft. 0 in. cc. of end bearings and the distance between centers of the top and bottom chords 13 ft. 0 in. The lifting weight of one truss was 30 tons. Owing to their over-all height of 15 ft. 6 in. and the desirability of their complete

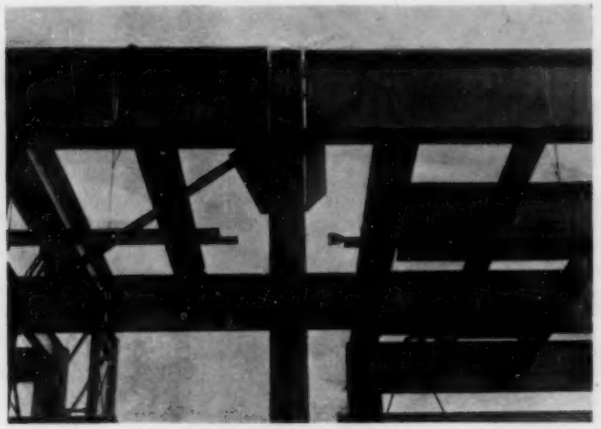


Fig. 5

fabrication in the shop it was necessary to secure two special platform cars for their shipment from Ambridge to Schenectady.

The principal load on these trusses is that of the mercury boiler which is hung from each truss on seven eye-bars. In addition the trusses support the roof and some equipment above the roof. The total load carried on each truss is 1,236,000 lb., most of which comes in along the bottom chord. This chord, which is subjected to a large bending moment in addition to the direct stress, is made up of two 36 CB 192 beams with a top cover plate, 26 x $1^1/_2$. The bottom covers are 10 x $1^1/_2$—one to each beam. The 7-in. eye-bars, which carry the boiler, go up between the two beams and the pins rest in saddles which bear directly on the top flanges of the chord. In order to connect the gusset plates directly to the webs of the beams it was necessary to block off the outside flanges at the ends and to cut a slot at the intermediate panel point.

The end posts and top chord were 14 CB 255 column sections with their ends milled to bear at the hip joint. All of the main gusset plates on the trusses were $1^1/_4$ in. in thickness. In each truss there were about 450 lin. ft. of welding.

The plate girders which support the trusses are somewhat unusual in that the stiffeners are on the inside between the double webs. Each girder is of the box type, built up of two web plates, 57 x $1^1/_2$, with top and bottom flange plates, 21 x $1^1/_2$, and the span, center to center of columns, is 27 ft. 0 in. Heavy strap plates on all four sides of the column provide an adequate tie between the girder and the column.

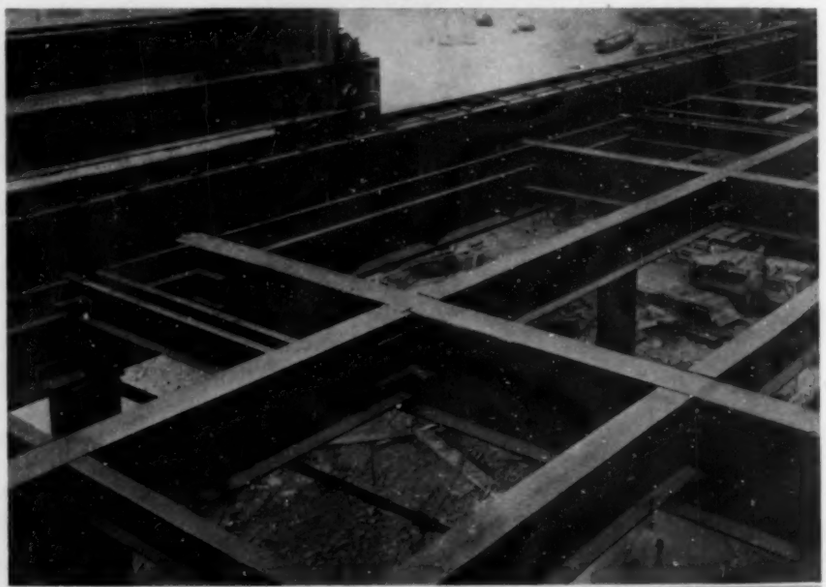
Figure 10 is a photograph of the trusses in their final location and shows the plate roof in position. The struts which provide the lateral support to the top chord may also be seen.

Figure 11 shows the stacks and bunkers during construction. Each stack is 10 ft. in diameter and lined with 2 in. of gunite. From the top to the point where it enters the sloping roof of the bunker is 97 ft. 6 in. and it continues downward for another 9 ft. 6 in. where it is anchored to the supporting girders. The coal bunkers are 28 ft. 0 in. in diameter with conical hoppers at the bottom and lined with 3 in. of gunite. The entire load is carried on the vertical ribs which are supported on plate girders.

The general details of the stack construction are given in Fig. 12. It will be noted that the lower portion is belled out to a diameter of 15 ft. 0 in. so as to decrease the stress in the plate and also the uplift from wind pressure. The top was stiffened and finished by welding a bar $3^1/_4$ x $^1/_2$ and an angle $3^1/_2$ x $3^1/_2$ x $^1/_2$ to the stack plate. In the sketches all field welds are designated by the letters *F.W.* and all shop welds either by the letters *S.W.* or without any designating letters.

The horizontal joints were of the shingle type. Holes were provided for temporary erection bolts, which served to hold the plates in position and to draw them together for welding. A continuous field weld was placed on the

Fig. 6—Crane Girder and Turbine Deck



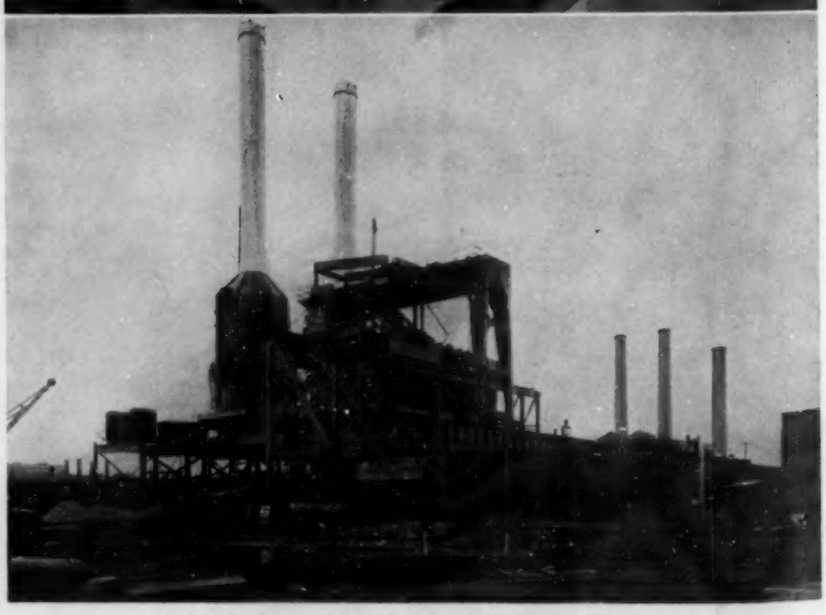
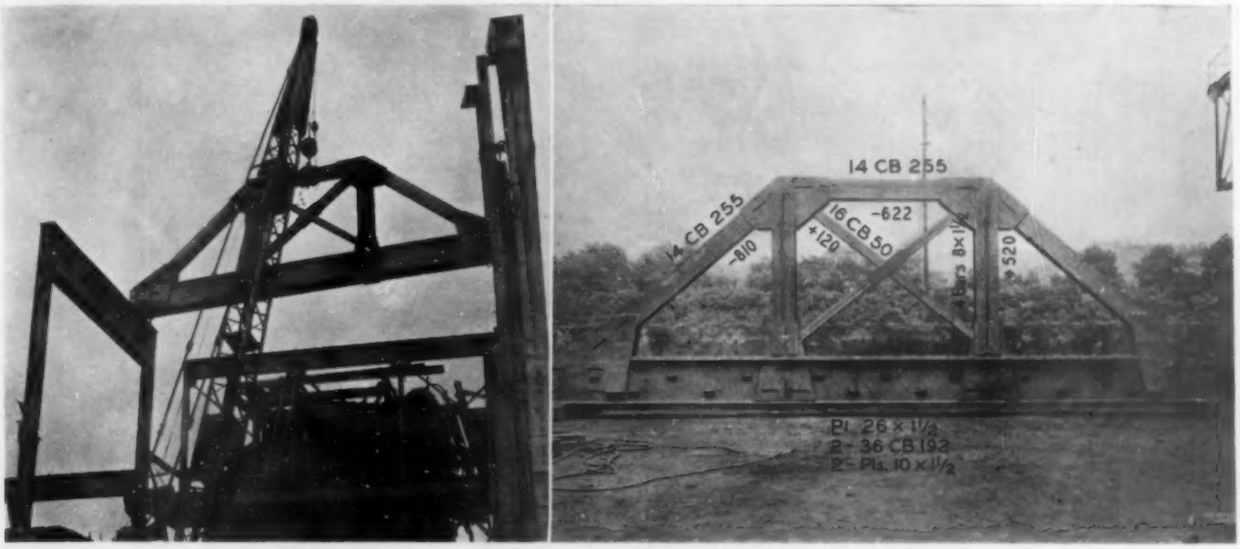


Fig. 7—Station Being Completed—Northwest Corner



Figs. 8 and 9—Thirty-Ton Steel Truss Being Placed to Support Mercury Boiler

inside of the joint while intermittent welds (which had to be made overhead) were used on the outside.

Each tier consisted of two plates, each forming a half-circle, which required two vertical splices per tier. The splices in adjacent tiers were staggered 90 deg. as shown on the sketch. It seemed best to use a splice plate for these joints. It was welded to one edge of the plate and a few holes were provided for temporary erection bolts. The $^{3}/_{16}$-in. shop weld served to hold the splice plate for shipment and was small enough not to interfere with a possible over-run on the abutting stack plate. A continuous fillet weld was placed on the inside by the field welders who also completed the butt joint between the edges of the stack plates.

Figure 13 is a photograph showing the short lengths of No. 8 bright wire, which were shop-welded to the inside surfaces of the stack plates. These wires were later used to fasten the gunite mesh to the stack.

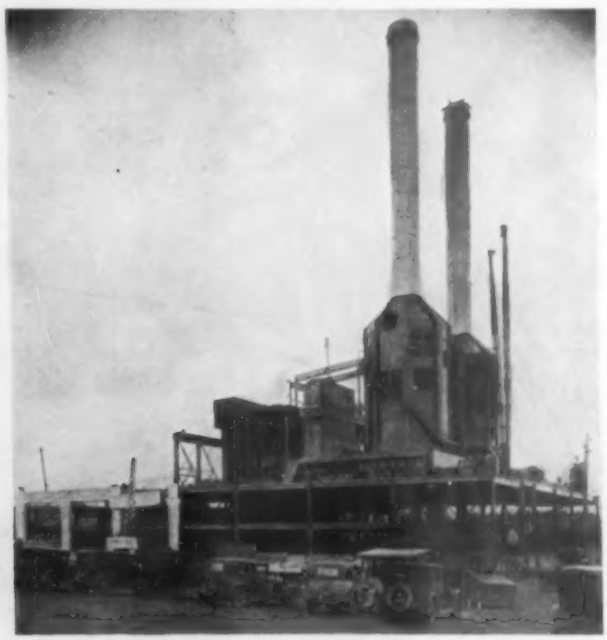
The general dimensions of the bunkers are shown in Fig. 14. The load is carried on the eight vertical ribs of 14 CB 103 column sections which, in turn, are supported in pairs on plate girders. The horizontal splices are stiffened with an angle, shop-welded to the upper edge of each tier plate. Temporary hook bolts were used to bring the upper plate into proper alignment for field welding. Rods to support the mesh for the gunite lining were put through the holes in the outstanding legs of the reinforcing angles. It will be noted that the lower edge of the bunker plate was beveled to permit better access to the joint for the field welding.

The vertical splices were made on each post and the method is clearly indicated in the sketch. At the base of the bunker is a horizontal ring girder, which takes the outward coal pressure and also carries the hopper.

Figure 15 is a view of one of the bunkers during construction. In the upper portion is a floor supporting the operating machinery for the coal hoist which rises in a chute within the bunker. Above that is a fan-room floor for the blowers producing the induced draft. Some rather intricate framing was required to support the heavy beams on these two operating floors. Access to these floors is by the outside stairs which are shown as partially erected in this figure and in their completed form in Fig. 11.

The corner column supporting the ends of two of the

Fig. 10 (Below)—Truss in Final Position
Fig. 11 (Right)—Steel Pilasters Being Placed



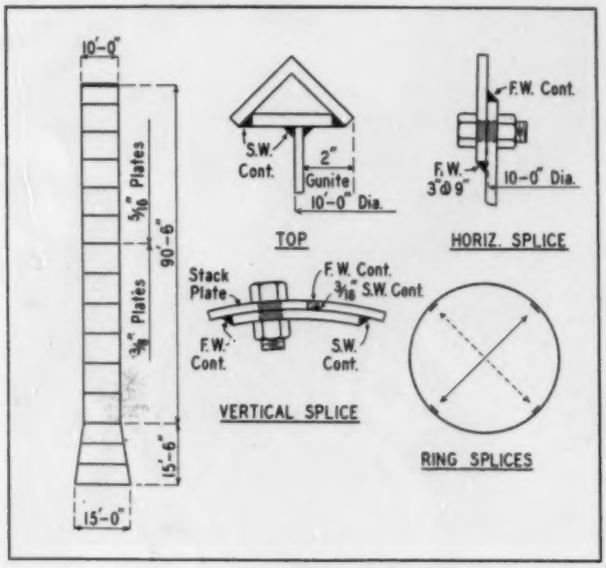


Fig. 12

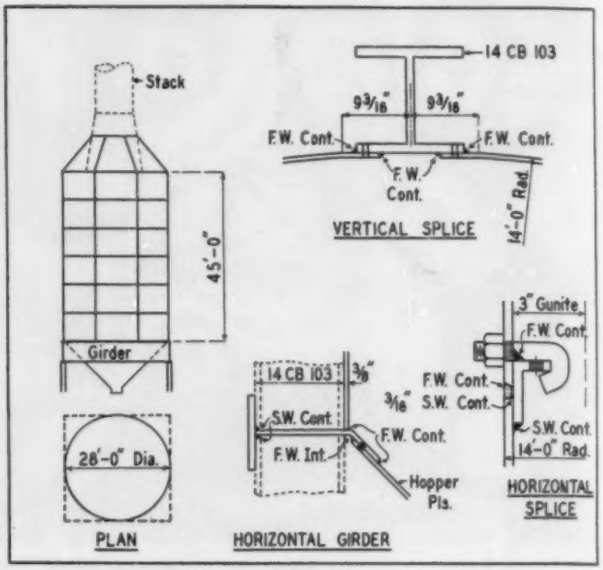


Fig. 14

Fig. 13

plate girders is shown in the photograph of Fig. 16. The first design contemplated a vertical welded-shear connection, but it will be seen that the loads are carried in bearing on a cap plate. Each girder is made up of a web plate, 64 x $^1/_2$, and flange plates, 18 x $1^1/_2$. Stiffeners are bars, welded intermittently to the web as shown and also welded at their ends to the flange plates. The seating of two heavy girders on top of a single column required considerable study before a satisfactory arrangement was adopted. The girder with its web parallel to the column flanges extends across the cap plate and its stiffeners are located over the column web. The stiffeners on the girder at right angles are over the column flange and the flange plates of the girder are cut back to clear the other girder. The two web plates are tied together by an angle which does not show in the

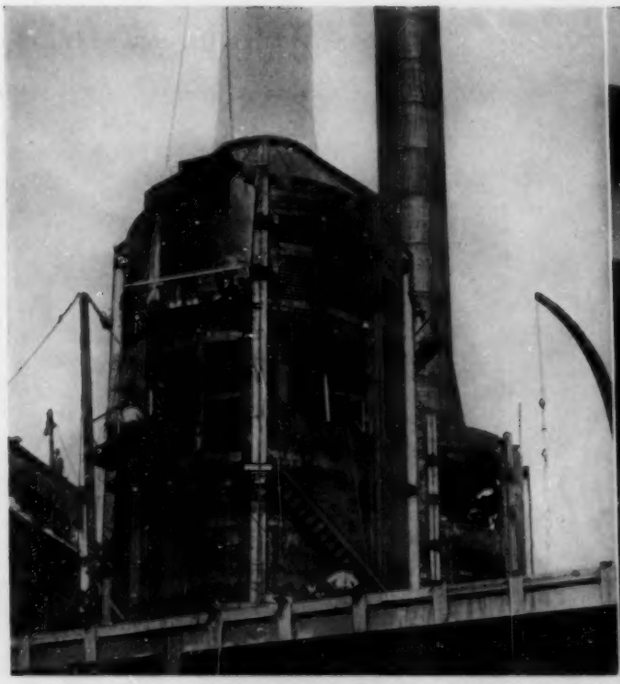


Fig. 15—Combined Coal Bunkers and Stack Bases, Being Fitted with Accessories

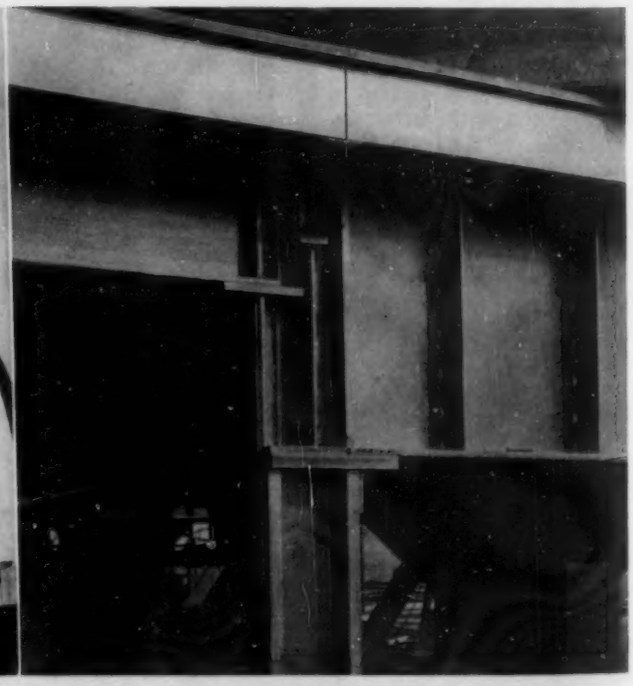


Fig. 16—Framing Details, Bunker Column Cap and Deck

picture. The load from a lighter plate girder is carried on the opposite flange of the column by means of a seat. Below the girder may be seen the conical bottom of the coal bunker with its rectangular gate box.

This paper has attempted only to point out some of the more striking features of an interesting structure. Obviously, no detailed analysis of the design is possible within the limits of time and space alloted to its presentation. It is hoped, however, that a study of the photographs and sketches will provide suggestions for the solution of similar design problems.

The Effect of Welding Current on the Fatigue Strength of Welds

By CHAS. H. JENNINGS

†Mr. Jennings is connected with the Research Laboratory of the Westinghouse Electric & Manufacturing Co.

Introduction

THE modern trend in arc-welding practice is toward better and faster welding. One of the best methods of obtaining this objective is by the use of automatic and semi-automatic welding equipment and increased welding currents.[1] The use of higher welding currents, however, is naturally accompanied with the question of its effect upon the strength of the welds.

It is the purpose of this article to present the results obtained from fatigue tests on 30° single vee butt welds made by the semi-automatic welding process by using welding currents of 200, 225, 250 and 275 amps.

Preparation of Specimens

The test specimens used were of the ordinary McAdam tapered cantilever type as shown in Fig. 1 and were machined from butt welded hot-rolled low-carbon steel plates 1 in. thick. These plates were 15 in. long, thereby making it possible to machine 10 specimens from each plate and still discard the end sections where the welds were started and finished.

All welds were of the 30° single vee type and were made by the semi-automatic welding process by using $^5/_{32}$-in. diameter uncoated welding wire. The welding currents used for the four series of tests were 200, 225, 250 and 275 amps. The arc voltage in all cases was 18–20 volts.

Discussion of Test Results

The endurance limit of each series of welds was obtained by testing the specimens in the usual manner and plotting an endurance curve from the data obtained.[2] Endurance curves for the four series of welds are shown in Fig. 2.

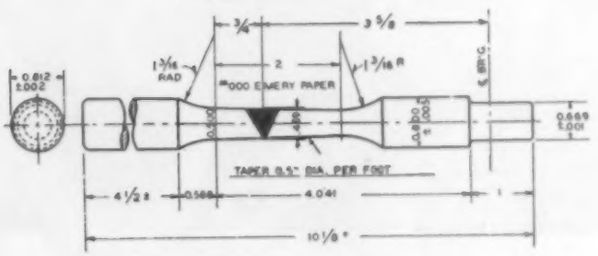
Endurance limits of the four series of welds are tabulated in Table 1.

Examination of Table 1 shows that there is only a slight variation in the endurance limit of the four series of welds. Within the 75-amp. current range investigated this variation is only 1100 lb./sq. in. and when one considers the amount of scatter and the irregularity obtained from fatigue tests on welds, it is obvious that this variation is within the allowable experimental error of the tests. On the basis of this fact, it can be concluded that the welding-current variation investigated has no large effect upon the fatigue strength of the welds.

Table 1—Endurance Limits of Semi-Automatic Butt Welds

Welding Current, Amps.	Endurance Limit, Lb/Sq.In.
200	19,100
225	19,900
250	18,800
275	18,900

Fig. 1—Cantilever Test Piece



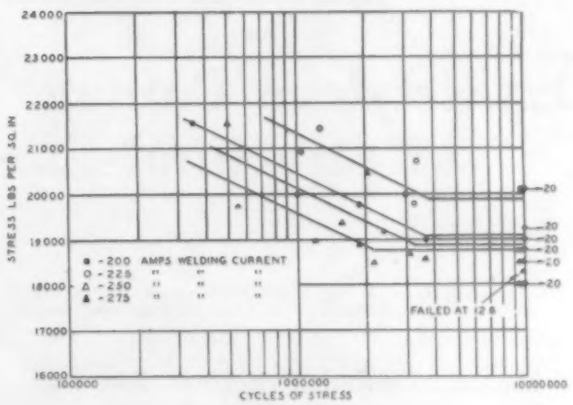


Fig. 2—Endurance Curves

Conclusion

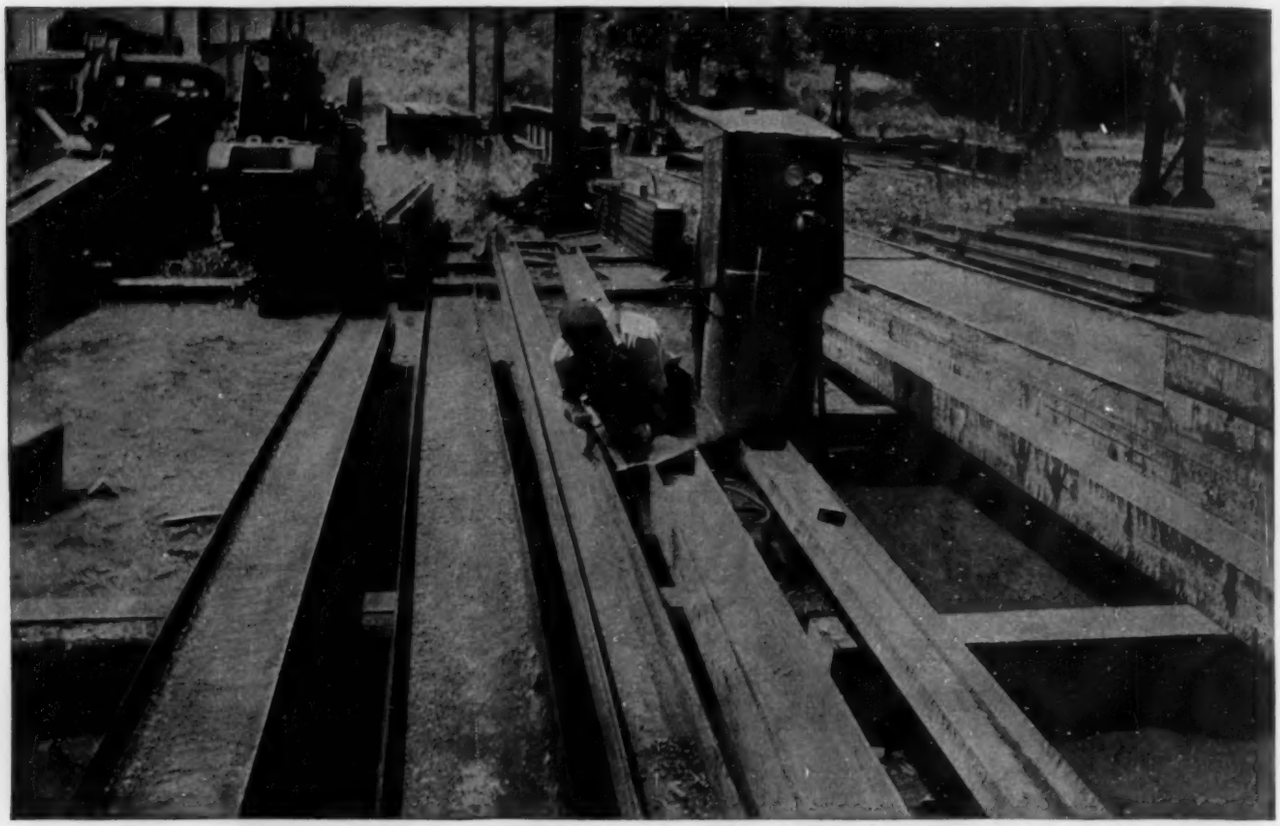
In summarizing the results of these tests, the following conclusions are obtained:

1. The endurance limit of 30° single vee butt welds made with uncoated $^5/_{32}$-in. diameter welding wire by the semi-automatic welding process is about 19,180 lb./sq. in. (average of 4 series of tests).

2. No large effect was obtained on the fatigue strength of semi-automatic butt welds of the type tested by varying the welding current from 200 to 275 amps.

[1] See A. M. Candy, "Modern Applications of Arc Welding," Symposium on Welding, Pittsburgh Regional Meeting, A.S.T.M. 1931 (Separate Preprint).

[2] See C. H. Jennings, "Fatigue and Impact Tests for Welds," JOURNAL OF THE AMERICAN WELDING SOCIETY, 9, No. 9, 103 (Sept. 1931).



Portable Oxyacetylene Equipment Provides a Time-Saving Cutting Method for Structural Steel

Oxyacetylene Cutting of Structural Steel

By **H. H. MOSS**

†Mr. Moss is with the Development Section, Engineering Department of The Linde Air Products Company.

Recommended Practices for Use of Cutting Blowpipes in Structural Steel Work

THE ease and economy with which ferrous metals, and especially steels, can be severed or shaped by the oxyacetylene cutting process has carried this tool into every activity of construction wherein these metals are employed. It has been of special facility in fabricating and erecting structural steel, and in repairing and altering existing structures. The widespread and general use of this tool by workmen at large has brought with it the need for recommended practices to insure its proper and safe use, so as to guide those using the process to avoid applications with the blowpipe that may unduly weaken a member of a steel structure, and to avoid practices in connection with the handling of the cutting equipment and cutting gases that may invite unsafe conditions where the cutting process is being used.

In drafting these recommendations liberal use has been made of the material in current regulations for gas cutting, promulgated by various regulatory bodies. Specific acknowledgment is made here to cooperation received from F. H. Frankland, Director of Engineering Service, American Institute of Steel Construction; to National Safety Council Safe Practices, Bulletin No. 23; to the Industrial Code, Bulletin No. 23, Rules Relating to the Erection, Repair or Demolition of Buildings of the Department of Labor, State of New York; to Code 1 Part A, Code for Fusion Welding and Gas Cutting in Building Construction of the AMERICAN WELDING SOCIETY; to the Report of the Oxy-Acetylene Committee of the International Acetylene Association for the year 1933.

An attempt has been made herein to deal with the essentials for general safety and good workmanship and, for the first time, to set up qualification tests for the predetermination of good or suitable workmanship. In dealing with the matter of cutting workmanship, these recommendations presuppose a knowledge on the part of those using the process of the fundamentals of the cutting process and functions of the cutting apparatus and its operation.

For the class of structures embraced herein, such as buildings, bridges and miscellaneous supporting frames and housings, concern as to the service of gas cutting has been centered mainly on two points: dimensional accuracy and regularity or smoothness of the cut surface. The qualification tests herein recommended provide a simple means for evaluating these two points of workmanship, which may be carried out in the average plant or field shop at nominal expense.

For a more extended account of the use and application of the oxyacetylene cutting process, reference is

made to the 1933 Report of the Oxy-Acetylene Committee of the International Acetylene Association.

I. Definitions*

Gas Cutting (*Oxyacetylene Cutting*).—The process of severing ferrous metals by means of the chemical behavior of oxygen, in the presence of ferrous metals at high temperatures, to produce a kerf or cut of uniform width without burning the edges of the kerf or cut. The term gas cutting signifies oxyacetylene cutting.

Cutting Process.—The means or method used to produce a cut.

Cutting Blowpipe or Torch.—A device used in the gas-cutting process for regulating and directing the oxygen-cutting jet and for mixing and regulating the combustion of the gases used for preheating purposes.

Cutting Nozzle or Tip.—That part of a cutting blowpipe adjacent to the cutting jet and preheating flame and through which the gases issue to atmosphere.

Kerf.—The space from which the metal has been removed by the cutting blowpipe.

Base Metal.—The parent material cut.

Acetylene Generator.—A portable or stationary device in the nature of a closed or water-sealed vessel used for generating acetylene direct from calcium carbide.

II. Recommended Practices

Gas cutting may be used in the fabrication, erection or repair, or alteration of structural steel members or parts used in building construction, bridges, supporting frames and housings in accordance with the following recommended practices:

1. Those undertaking gas cutting within the scope of these recommendations, such as the General or Erection Contractor, or those employed in erection departments of industrial shop organizations, or subcontractors employed for the repair or alteration of structural steel, shall demonstrate their ability to produce gas cuts of satisfactory quality.

2. The quality of gas cuts permitted hereunder shall conform to the practices set out herein. In no case shall the quality be lower than that required in Qualification Test No. 1 for full (unguided) manual cutting, and as required in Qualification Test No. 2 for guided manual cutting, as set out in Section III herein.

3. Gas cutting shall not be permitted in any member or part of erected structures embraced within these recommendations without the approval of a responsible architect, engineer or authorized building inspector.

4. Gas cutting shall not be permitted on any member while it is under load. This restriction shall not apply to detail cutting for the correction of minor fabricating errors or additional rivet or bolt holes, where the removal of metal resulting from such gas cutting would not reduce the required strength of the member that is to be cut.

5. Gas cutting of any member or part to form openings or to remove portions of flanges shall not be done unless the design provides therefor.

6. Gas cutting may be used to form bolt holes provided the holes are made uniformly smooth and the dimensions and alignment of the holes are equivalent to those required for punched holes.

7. Gas cutting may be used to form rivet holes provided they conform to the dimension tolerances required for punches or drilled rivet holes.

8. Gas cutting may be used to remove rivets provided in so doing the thickness of the base metal about the rivet is not reduced.

9. All interior terminals or ends of noncircular gas cuts, and all interior melting points or junctions of gas cuts shall be uniformly rounded to form smooth fillets having a radius of not less than 1 in.

10. Gas cutting in primary members shall be performed with the aid of a straight-edge or suitable guide whenever the continuous length of the cuts is greater than 3 in. measured in a straight line, or where the diameter of a hole to be cut exceeds 3 in. This restriction shall not apply to detail gas cuttings about beam and girder copings and endings which provide insufficient clearance for proper field assembly, provided, however, that the requirements of Par. 9, herewith, are fulfilled.

11. No structural steel member or part of any structure within the scope of these recommendations may be gas cut except by those customarily engaged for steel erection, repair or demolition.

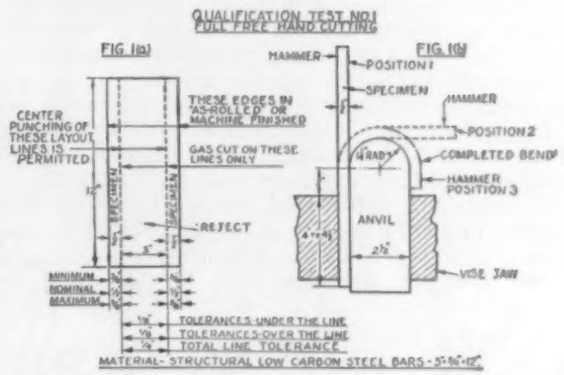


Fig. 1(a) and (b)—Qualification Test No. 1 for Full Free-Hand Cutting

12. Upon the occasion of any question of workmanship during the course of erection, repair or alteration of a steel structure, those performing the cutting may be retested to prove the adequacy of their skill by Test No. 1 and/or No. 2 as set forth in Section III herein.

III. Qualification Tests for Workmanship

In evaluating gas cuts in plain low-carbon steel from the standpoint of their serviceability in structures there are two points of principal concern. One deals with the accuracy of the cut, referred to predetermined dimensions, profiles or layouts; the other consists of the smoothness or regularity of the cut edge or surface. Accuracy in cutting, in turn, determines the accuracy in which steel members or parts can be fitted together or framed, whereas smoothness of cutting is a measure of the service which a cut can perform under load or stress. If the cut is very rough or irregular there is liability of cracking at the low sections of the irregularities along the cut, when the cut is under extreme load, or deformed or bent when cold. This, when it occurs, is due to concentration or the building up of stress at these low spots as compared with even distribution of stress along smooth uniform surfaces.

In view of the possibility of inducing incipient cracks in the surface of cuts through improper workmanship, the degree of regularity of cuts should be measured and suitable limits provided therefor. This has been done in these Qualification Tests.

The amount of bend which the cut surfaces are required to develop is considerably more than that which structural materials ordinarily encounter in service.

* These definitions are in substantial agreement with those for similar terms published by the American Welding Society in their bulletin entitled "Welding and Cutting Nomenclature Definitions and Symbols."

This has been done to insure a good margin of safety for all practical purposes.

Qualification Test No. 1

(Full Free-Hand Manual Cutting)

1. This test requires the cutting, by means of an oxyacetylene-cutting blowpipe, of two test specimens from $^3/_4$-in. low-carbon steel plate of structural grade, $^1/_2$ in. wide by 12 in. long, as shown in Fig. 1*a*. The inside face only of these specimens is to be gas cut, the outside face to be in the "as-rolled" condition, or machined smooth.

2. The method of cutting shall be fully manual, that is, no guides or straight edges other than the cutter's hand are to be used. The cutting equipment shall be in good workmanlike condition, and the gas pressures employed shall conform closely to those specified by the manufacturers of the cutting blowpipe. The dimensional requirements for accuracy shall conform to the tolerances specified in Fig. 1*a*. The squareness of cut, cross sectionally, shall be within 5 deg. or approximately $^1/_{16}$ in. in $^3/_4$ in., when measured against the top surface of the metal cut.

3. Upon completion of cutting, the specimens shall fall free of the base metal from which they were cut without the aid of a hammer or other tool, and the bottom edge of their cut faces shall be reasonably free of adhering slag. When cold, the specimens are to be cleaned of any adhering slag in preparation for bending, as shown in Fig. 1*b*. Under these conditions, the specimens are to be placed in a vise (Fig. 1*b*, Position 1), and bent completely around a $2^1/_2$-in. radius anvil (Fig. 3) to Position 3 of Fig. 1*b*.

4. To qualify, a cut specimen shall meet the dimensional tolerances specified in Fig. 1*a*, the squareness specified in paragraph 2 above, and its gas-cut surface shall withstand the amount of bending indicated by Position 3 of Fig. 1*b* without cracking.

5. Small fractures at the extreme margin or edges of the cut surface shall not disqualify a specimen, since there is known to be a high concentration of stress along these margins under the bending conditions set forth, which is relieved as soon as small ruptures in these extreme fibres take place.

Qualification Test No. 2

(Guided Manual Cutting)

6. This test requires the cutting, by means of an oxyacetylene-cutting blowpipe, of two specimens from a $^3/_4$-in. low-carbon steel plate of structural grade, $^1/_2$ in. wide by 12 in. long, as shown in Fig. 2*a*. The inside face only of these specimens is to be gas cut, the outside face to be in the "as-rolled" condition or machined smooth.

7. The method of cutting shall be manual but the cut shall be made with the aid of a suitable straight-edge guide clamped or otherwise secured to the base metal being cut. The cutting equipment shall be in good workmanlike condition and the gas pressures employed shall conform closely to those specified by the manufacturers of the cutting blowpipe. The dimensional requirement for accuracy shall conform to the tolerances specified in Fig. 2*a*. The squareness of cut, cross sectionally, shall be within $2^1/_2$ deg. or approximately $^1/_{32}$ in. in $^3/_4$ in., when measured against the top surface of the metal cut.

8. Upon completion of cutting, the specimens shall fall free of the base metal from which they were cut without the aid of a hammer or other tool, and the bottom edge of their cut faces shall be reasonably free of adhering slag. When cold, the specimens are to be cleaned of any adhering slag in preparation for bending, as shown in Fig. 2*b*. Under these conditions, the specimens are to be placed in a vise (Fig. 2*b*, Position 1), and bent completely around a 2-in. radius anvil (Fig. 4) to Position 3 of Fig. 2*b*.

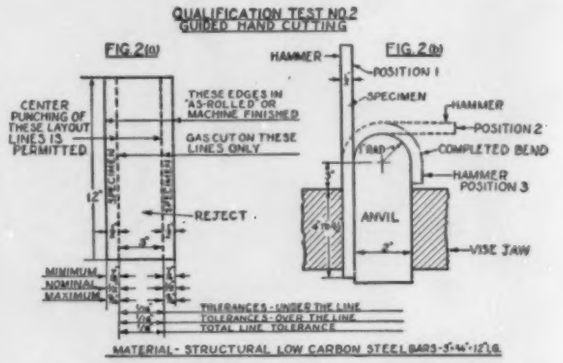


Fig. 2(a) and (b)—Qualification Test No. 2 for Guided-Hand Cutting

9. To qualify, a cut specimen shall meet the dimensional tolerances specified in Fig. 2*a*, the squareness specified in Paragraph 7 above, and its gas-cut surface shall withstand the amount of bending indicated by Position 3 of Fig. 2*b*, without cracking.

10. Small fractures at the extreme margin or edges of the cut surface shall not disqualify a specimen, since there is known to be a high concentration of stress along these margins under the bending conditions set forth, which is relieved as soon as small ruptures in these extreme fibres take place.

IV. Safety Precautions

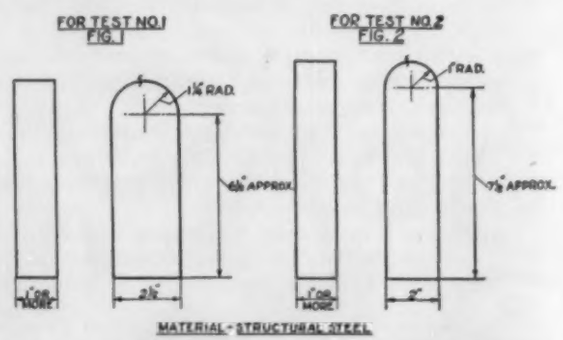
As a safeguard against fires and accidents during building construction, repair and demolition, the following precautions shall be observed in the use of the gas-cutting process:

Rule 1: For gases under pressure—only cylinders which comply with Interstate Commerce Commission shipping container specifications shall be used.

Rule 2: In the use or storage of charged cylinders, care shall be taken to prevent tampering by unauthorized persons or damage by falling objects.

Rule 3: Cylinders shall not be exposed to sparks or flames either from the welding or cutting operation or from any other source. Charged cylinders shall not be placed near boilers, furnaces or forges, or near readily flammable material.

Rule 4: Cylinders when moved from one portion of a structure to another shall be protected with such caps for valves as are required by the Interstate Com-



Figs. 3 (left) and 4 (right)—Bending Anvil for Test Specimens

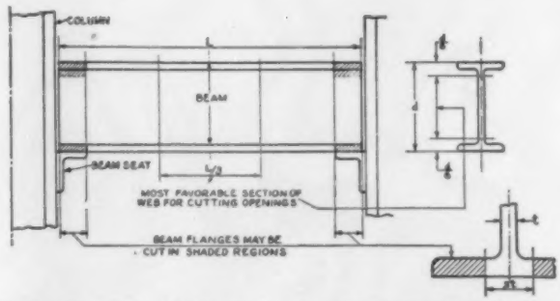


Fig. 5—Flanges Can Be Trimmed or Coped in the Vicinity of Supports

merce Commission specification unless securely mounted on a special truck or other suitable transporting device. Regulators shall be removed when the outfit is moved unless cylinders are securely mounted on such truck or other suitable transporting device.

Rule 5: Cylinders when in use shall be located reasonably close to the work so as to avoid undue lengths of hose.

Rule 6: Cylinders in use on structures shall be securely lashed in place when necessary to prevent them from falling to a lower level.

Rule 7: Each cylinder connected for use with a blowpipe or torch shall have an automatic regulator or reducing valve attached directly to the cylinder valve with or without an adaptor.

Rule 8: When cylinders are connected to cutting equipment but such equipment is not in use the cylinder valves shall be shut and pressure released from the reducing or regulating valves.

Rule 9: **Important Warning**—Oily or greasy substances shall be kept away from oxygen cylinders, cylinder valves, couplings, regulators, hose and all other oxygen apparatus.

Rule 10: Where cutting operations are progressing proper precautions shall be taken to prevent metal or slag from falling on persons or on combustible material.

Rule 11: Suitable eye protection shall be used by the workmen actually employed in the cutting operations.

Rule 12: Cutting blowpipes or torches, regulating or reducing valves, pressure gages, acetylene generators (when permitted), hose and couplings shall be of a type listed as standard by Underwriters' Laboratories, Inc., or by the Associated Factory Mutual Fire Insurance Companies.

Rule 13: Reserve stocks of oxygen shall not be stored alongside of reserve supplies of acetylene or other fuel gas cylinders. If calcium carbide is stored on the premises, the current regulations of the National Board of Fire Underwriters, relating thereto, shall be followed.

Rule 14: Where acetylene generators are used the current regulations of the National Board of Fire Underwriters as to the installation and operation of such generators shall be followed.

Rule 15: Handling Cylinders:

1. Cylinders of compressed gas shall be handled carefully at all times.
2. When handling cylinders by a crane or derrick, a cradle, boat or suitable platform shall be used, but electric magnets or slings shall not be used.
3. Cylinders whether charged or empty shall not be used as rollers, skids or supports.

Rule 16: Storing Cylinders:

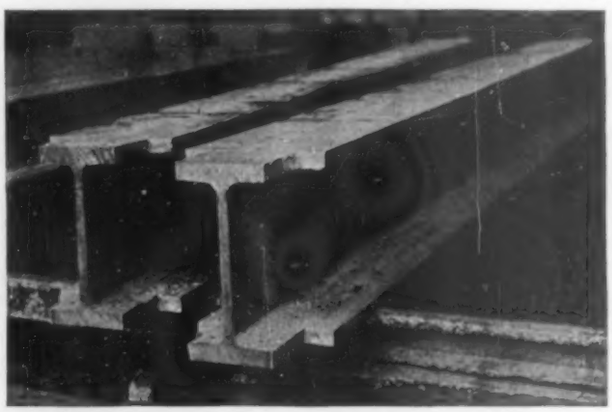
1. Charged cylinders shall be stored in well-ventilated cool locations and away from elevators, other openings or gangways.
2. Charged cylinders shall not be stored where they are exposed to extremes of temperature.
3. Open lights or flames shall not be placed where charged cylinders are stored.
4. Valves on empty cylinders shall be kept closed.
5. Cylinders or valves shall not be altered or repaired except by the manufacturer.

Rule 17: Care of Cylinders and Apparatus:

1. Tops of concave head cylinders shall not be used as receptacles for tools or other material. The valves shall be accessible for quick shut-off at all times.
2. The connection between the regulator and the cylinder valve shall be a gas-tight joint. If there is a leak, the gas shall be shut off at the cylinder before tightening the joint.

NOTE: To make the test for leak, release pressure adjusting screw in the regulator and open the cylinder valve slowly. Then test connection with soapy water or equivalent liquid. Never use a flame of any kind.

3. Equipment such as blowpipes, torches and regulating or reducing valves should be stored and taken care of when not in use.
4. When a new cylinder of compressed gas is connected to the apparatus, be sure to open the valves on the blowpipes or torches a sufficient time before lighting to purge hose of any mixtures that may be present.
5. If apparatus is found to be defective, the operator shall close the cylinder valves and then immediately notify the person in charge.
6. The hose connecting blowpipes to gas outlets shall be of sufficient strength to sustain a test pressure of at least 400 lb. per sq. in. maintained for five minutes. Armored hose shall not be used.
7. The connections between the hose and fittings shall be securely made with suitable clamps or ferrules.
8. Hose shall be so located or protected as to prevent accidental damage by trucks, wheelbarrows, etc. Hose shall be kept free from tangles and kinks.



Beam Ends Are Rapidly Prepared by Means of the Blowpipe

Rule 18: Special Suggestions for Acetylene Cylinders:

1. Acetylene cylinders shall be stored and used with valve end up and shall not be allowed to lie on their sides.
2. Do not tamper with the fuse plugs or other fittings which form parts of cylinders.
3. To get the full flow of gas from an acetylene cylinder it is unnecessary to open the cylinder valves more than $1^1/_2$ turns. Keep the valve key on the valve spindle or stem when the cylinder is in use.
4. On an acetylene cylinder the threads of the

cylinder valve are generally left-handed. If the acetylene regulator does not fit the cylinder valve a proper adaptor should be used.

Rule 19: Special Suggestions for Oxygen Cylinders:

1. WARNING—Keep oxygen away from oil or grease. Oil or grease in presence of oxygen under pressure will ignite violently.

2. Oxygen shall never be used as a substitute for compressed air or as a pressure-imposing medium.

3. Do not tamper with or attempt to repair oxygen valves.

4. Always operate oxygen cylinders with the valves wide open.

V. On Cutting Practices

1. Since cutting action is dependent upon the chemical reaction between the metal and the oxygen, it is desirable that the surface of a part to be cut should be cleaned before attempting to cut. Dirt and scale, if any, other than ordinary mill scale, should be scraped off or removed with a stiff wire brush. Heavy layers of paint tend to slow down the cut and annoy the operator by fuming.

2. Clean and workmanlike cutting is greatly facilitated when the proper size blowpipe nozzle and oxygen pressures are observed. The following table provides a guide for cutting the normal range of thicknesses encountered in average structures:

Thickness of Metal, In.	Size* of Cutting Nozzle, No.	Oxygen Pressure, Lb. per Sq. In.
1/4	1	20
3/8	1	25
1/2	1	30
3/4	2	35
1	2	40
1 1/2	2	45
2	2	45
3	2	55
4	3	65

* Nozzle sizes are those for Oxweld cutting blowpipes.

3. For fully manual cutting, accuracy in cutting is improved by center punching the line of cut at close intervals. This aids the cutting operator in recognizing the line of cut more easily.

4. In cutting through flange and web junctions of beams, girders and columns, better results as to regularity of cut will generally obtain if a small round port or hole is first cut through the web on the desired line of cut as close as possible to the inside face of the flange. This serves to exhaust the cutting oxygen and products of combustion uniformly when passing these junction points as a cut progresses across a flange.

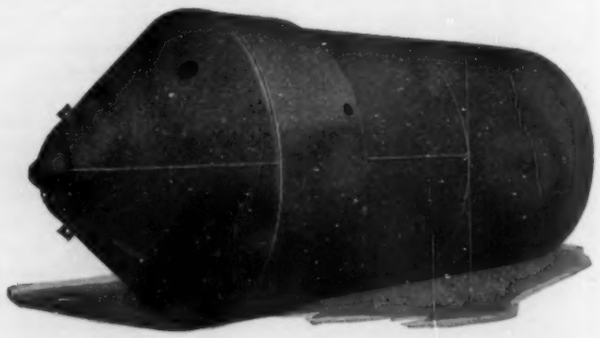
5. Beam and girder flanges should never be cut between supports unless especially provided for in the design of the beam or girder. Flanges may be trimmed or coped in the vicinity of supports as shown in Fig. 5 without endangering the beam or girder provided the beam or girder is otherwise suitably connected to the column or member in which it frames.

6. Holes or openings should never be cut in beams, girders or columns unless the design therefor specifically provides for these openings; if permissible, or in designing therefor, they should preferably be located in the middle section of the web as shown in Fig. 5.

Soap Manufacturer Chooses Stainless-Clad Steel for Glycerin Bleach Tanks

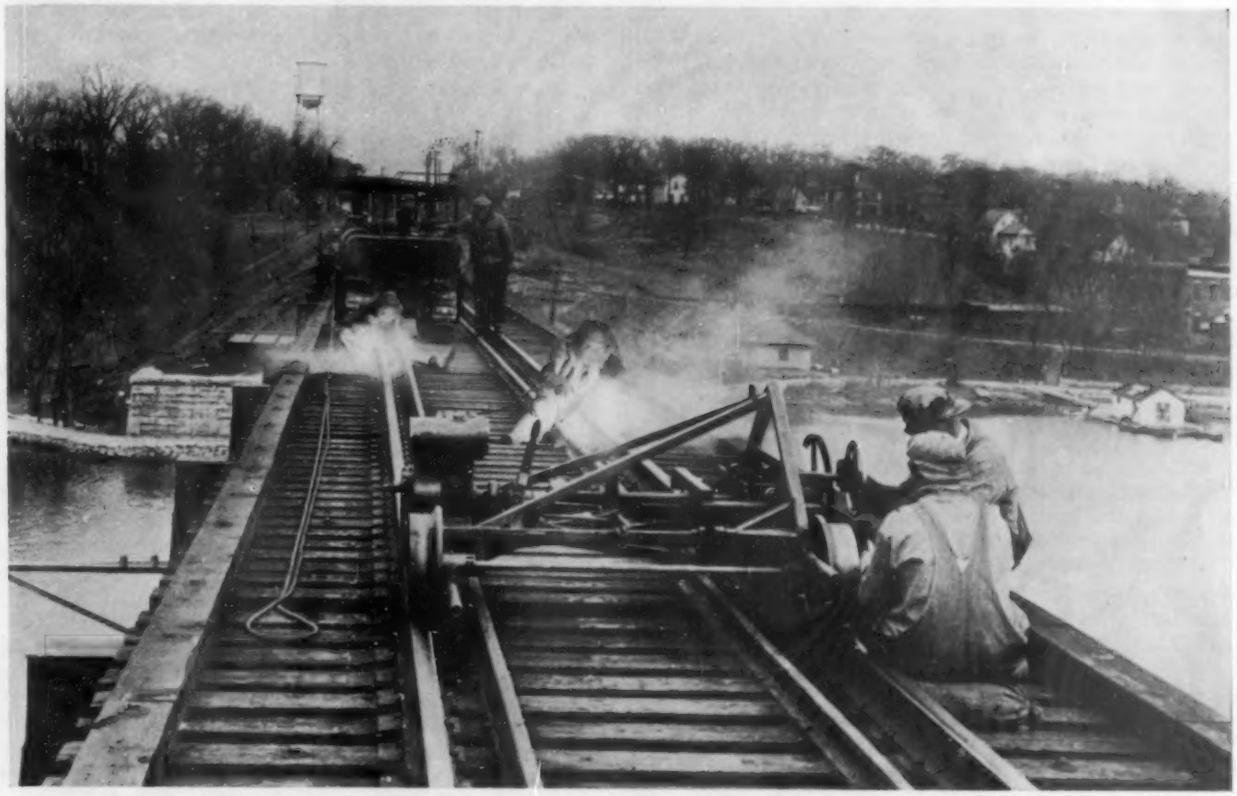
By **WILLIAM B. KEELOR**

†Mr. Keelor is Welding Engineer for the Ingersoll Steel & Disc Company.



EVER widening uses for the corrosion-resistant alloys in the process industries is indicated by the recent installations of a 20,000-lb. capacity C.P. bleach tank in the plant of one of the large mid-western soap manufacturers. The tank, used in the refining of glycerin is 6 ft. in diameter by 13 ft. long, with a water-jacketed conical bottom. The vessel, fabricated by the Hamler Boiler and Tank Company of Chicago, was made of all-welded stainless-clad steel. One-quarter-inch clad steel was used for the shell and bottom, and 3/16-in. clad material formed the water jacket. All welds were ground throughout. The jacket was tested to 50-lb. hydrostatic pressure.

This is but one of several similar installations within the soap industry that have recently specified stainless-clad steel to meet their conditions as to corrosion resistance. Initial economy of the material has been a further factor in the selection of stainless steel for various uses within the industry which have included pressure vessels, centrifugal separators and tanks.



Restoring Battered Rail Ends by Welding

By **B. C. TRACEY** *and* **O. A. TILTON**

+ Messers Tracey & Tilton are connected with the Industrial Engineering Dept. of the General Electric Co.

SUITABLE welding electrodes have been developed for restoring battered rail ends to their original contour quickly and cheaply. The deposited metal has high resistance to impact and abrasion and responds to the cold working of wheel batter even more satisfactorily than the rail itself. The analysis of the deposit is 1.35 manganese and 0.25 carbon. Its tensile strength is 105,000 lb. per sq. in. and impact value 20 ft.-lb. These latter values were, of course, obtained from all-weld metal specimens. It is expected that its impact value as deposited on a rail would be slightly lower with a corresponding increase in tensile strength, due to a probable increase in carbon by migration from the rail. Its hardness averages 305 Brinell when deposited on a rail of 268 Brinell, a most desirable ratio for this property. If, for instance, the deposit were, say, 500 to 560 Brinell, there would be a tendency for it to crack and "spall" off under the cold working caused by the wheels. If it were softer than the rail, it would batter down quickly and be of little use.

The electrode is of the heavily coated type sometimes called the "shielded arc" type. With it, an average joint 8.5 in. long on a 130-lb. rail can be welded in $10^1/_2$ min. Finishing the joint by grinding requires from 5 to 6 min.

The following example of battered rail-end welding is taken from the experience of a railroad near Chicago. In this case 34 miles of track have been reclaimed by welding. The track is of standard 100-lb. rails. Using $^1/_4$-in. diam. electrode, 225-amp. welding current and a 43-volt arc, a welding speed of 61 rail-inches per man per hour was accomplished. The average length of joint in rail-inches was 13.6. Operating speed on this kind of work should always be stated in this way. If stated in the number of joints completed per man per hour or per day, there would be no clear indication of the performance. In cases of only a moderate amount of batter, the length of joint may be as low as $8^1/_2$ in., whereas in the example just cited the joints averaged 60% greater in length. Approximately 9800 lb. of electrode were required on this 34 miles of track reclamation work.

Much could be said about the sequence of operation, the kind of grinding tools to be used and other similar operating details. Welded rail ends must, of course, be finished by grinding and the joints cross-slotted. However, the matter of organizing a gang and the type of grinding equipment to use is a problem that is tied up with management policies and local conditions.

It seems in order, however, to comment briefly on the type of welding equipment that seems well adapted to this kind of work. The direct current variable voltage type of generator is recommended because it is self-regulating and for this class of work its flexibility and ease of adjustment for each new condition are very desirable characteristics.

Gasoline engine-driven equipment is usually most

desirable because of the difficulty of obtaining electrical power lines along the right of way. A very convenient form of engine-driven welding unit consists of a standard type of crawler tractor with one or sometimes two welding generators mounted on it and driven by V-belts from the power take-off of the tractor. Such a unit moves along the right of way, keeping fairly close to the welders and requires only 100 ft. of leads for each operator. It can be quickly moved out of the way to permit trains to pass and climbs embankments, crosses rails and may be moved across bridges readily. Such a unit is usually moved about 12 times a day.

Another type of welding unit is mounted on flanged wheels to go directly on the track. It is, therefore, provided with the standard type of cross wheels, so that it can be rolled off the line when necessary. In all other respects it resembles the tractor unit just described. With this type of unit longer welding leads must be used to reduce to a minimum the number of times the unit must be moved each day. Two-hundred-ft. leads are best, but under the best of conditions they may be from 400 to 500 ft. in length.

It seems probable that grinders should have a source of power supply independent of the welding units as the grinding operation may sometimes be as much as a mile behind the welding.

The crew on each welding outfit will usually consist of a welding operator, one grinder and a supervisor. This, of course, varies with the number of welding machines in a group as well as the traffic conditions. When such operations are on a 24-hr. basis it may be advisable to work in 4 shifts of 6 hrs. each, using 2 complete crews.

The technique of building up battered rail ends by electric welding is not complicated. The procedure recommended is to apply the deposited metal in a wide flat bead, starting at one corner of the rail end and proceeding diagonally in parallel beads up to the other corner of the rail end, then starting at the opposite corner of the pad proceed diagonally with beads parallel to those already laid, until the pad is completed. In this way, the effect of heat on the rail is minimized and, at the same time, the deposit is laid diagonally to the direction of impact. The average rail end requires building up from 0.07 to 0.08 in.

The useful life of rails is more than doubled by electric welding of the battered ends. Experience has shown that the rebuilt rail will give longer service than new rail because of the durability of the deposited metal and the added hardness of the deposit over that of the original rail.

Battered rail-end welding should not be done in the coldest part of the year. Not only are the rails themselves in a rather critical state at low temperatures, but also the weld metal, being of a similar physical make-up, is subject to the same temperature effects.

A welding operation that can be carried on throughout the year, and indoors in the winter, is the repairing of worn and broken manganese frogs, switches and crossovers. This brings us to another phase of the subject of hard surfacing by welding. These castings are very costly and their replacement has formerly been the only alternative when wear or breakage has rendered them no longer serviceable. Welding electrodes and a process have, however, been developed which are suitable for manganese steel and it is now possible to bring these worn parts in to a central point, where they are repaired to be as good as new.

The electrodes include a bare manganese rod and a heavily coated type. These two kinds are provided to cover the need of a narrow, high bead in the first case and wide, thin bead in the second.

The chemical analysis of the electrode itself is 14.0% manganese, 1.3% carbon, 5.0% nickel and 0.35% silicon. That of the deposit is 12.8% manganese, 1.04% carbon, 4.37% nickel and 0.53% silicon.

Manganese steel castings contain about 12.5% manganese and 1.25% carbon. They also usually contain varying amounts of silicon in the form of sand, inasmuch as they are difficult castings to produce. In their "as-cast" condition, they are very brittle. To relieve this condition they are "soaked" in a furnace for a long period at around 1850° F. and then quenched in water. The long heating at this high temperature dissolves into austenite the free carbides which would otherwise render the steel weak. This austenitic structure is fixed by cooling so quickly that the carbides cannot again precipitate.

Reheating a treated manganese steel casting tends to embrittle it and the damage so done can only be repaired by repeating the original heat treatment. This is brought out to show that low heat and careful application are required when welding such materials. The high-nickel content in the manganese welding electrode permeates the zone of affected parent metal adjacent to the weld and largely corrects the otherwise changed metal structure resulting from the heat of welding.

Manganese electrodes are applied with as low a welding heat as is consistent with good penetration. The recommended current values are 100 to 125 amp. on 1/8-in. electrode, 125 to 150 with 5/32, 150 to 160 with 3/16 and 160 to 175 amperes with 1/4-in. diam. electrode. A short arc is best and the weld metal should be puddled by a semi-circular motion of the end of the rod. Excess heat causes bubbling and may be retarded by touching the electrode to the molten pool intermittently. Such welds should be hammered vigorously while hot. This tends to equalize locked-up stresses. Craters should be filled. The joint should be prepared with a wide angled "V" and ground clean, as well as thoroughly wire brushed to remove all rust, scale or other foreign matter. Frequent brushing while the weld is being made is desirable. Weld only a short time in one spot and then go to some other part of the casting so as to keep the heat as low as possible. Careful grinding is as important as making the weld itself, as the best welds can be ruined by careless grinding.

Although attention has been concentrated so far on the application of manganese electrodes to railroad rails and accessories, there are many other places where this form of wear-resisting deposit may be used to great advantage. It can be used equally well for applying a manganese steel surface to ordinary iron and steel, thereby providing a tough, work-hardening area at low cost.

The field for application of this type of electrode is large in that equipment subject to impact wear combined with abrasion wear can be restored for long and useful service.

Engraved Certificates of membership 9 in. by 12 in. suitable for framing are now available. Order for certificates should be placed with the Secretary.

Welding of Structural Nickel Steel

By W. L. WARNER

†Paper was presented at Fall Meeting, American Welding Society, Detroit, Oct. 2nd to 6th, by W. L. Warner, Watertown Arsenal.

THE term "structural nickel steel" may be somewhat broadly interpreted to include a variety of nickel steel alloys of varying nickel and carbon contents, i.e., from 1 to 3½% nickel and 0.10 to 0.50% carbon. However, in the present discussion the remarks will be confined to the structural nickel plate material used at Watertown Arsenal for the building of ordnance structures.

This alloy falls approximately in the class designated by S. A. E. 2335—nickel, 3¼–3¾%; carbon, 0.30–0.40%; manganese 0.50–0.70%; phosphorus and sulphur, maximum 0.04 and 0.05%, respectively; and silicon 0.15%.

The general specifications to which this material is obtained set the following limits of chemical composition:

Carbon, Max.	Manganese, Max.	Nickel, Min.	Phosphorus, Max.	Sulphur, Max.
0.45%	0.70%	3.25%	0.05% acid 0.04% basic	0.05 0.05

Minimum physical properties are required as follows:

Minimum T. S. lb. per sq. in.	85,000
Minimum Y. P. lb. per sq. in.	1/2 T. S.
Minimum Elongation in 8 in.	$\frac{1{,}500{,}000\ \%}{\text{T. S.}}$
Minimum Elongation in 2 in.	18%
Minimum Reduction of Area	25%

The steel may be either open hearth or electric and is generally obtained in the "as-rolled" condition because of greater stiffness of the material.

Chemical analysis of miscellaneous samples of plate taken from the welding shop usually shows the nickel content to be between 3.3 and 3.6% with the carbon ranging between 0.30 and 0.45%. Tensile tests of similar samples usually show the following results:

Tensile Strength	95–105,000 lb. per sq. in.
Prop. Limit	50–55,000 lb. per sq. in.
Elong. 2 in.	20%
Elong. 1 in.	30–35%
Reduction of Area	35%

The welding of this structural nickel plate presents no great difficulty as far as applying weld metal is concerned. In fact, from an observation of the arc action and the external appearance of the weld made with commercial types of low-carbon electrodes, one would be unable to judge definitely as to whether the base metal was structural carbon or nickel steel plate. It is only when comparisons of weld metal densities, microstructure and physical properties are made that the differences become apparent.

The photomicrographs of Figs. 1 and 2 show the structures of carbon and nickel steel plate at 100 and 1000 diameters. These specimens were taken at random and the analyses are as follows:

Figure 1—0.23% C, 0.35% Mn, 0.015% Si
Figure 2—0.43% C, 0.61% Mn, 0.160% Si, 3.5% Ni

The carbon steel shows relatively large ferrite grains with numerous small pearlitic areas between and the separation between the two is very distinct, the ferrite grains being very sharply defined. The nickel steel shows a sorbitic structure with a high concentration of cementite particles in ferrite in certain local areas surrounded by ferrite grains which are considerably smaller than those of the carbon steel and not so sharply defined. The nickel presumably is in solid solution in the ferrite. This material has air hardening properties due to the carbon content and the presence of nickel which shows up the transformation from one metal structure to the other on cooling. Welds on this material will produce extreme hardening in the heat-affected zones adjacent to the welds unless preheated and slowly cooled.

The type of test used to determine the strength of a material or that of a joint in the material depends upon the data desired, how this data is to be used and the kind of service to which the material or joint is to be subjected in the finished structure.

For general design purposes the tensile test is used, except in the case of fillet welds, where the shearing strength is used as the basis of design. Forms of specimens have been standardized for tests of materials of construction by engineering societies and other agencies, but the testing of welds presents problems of interpretation, non-homogeneity and stress distribution which require further consideration. The basic problem from the design standpoint is how to determine the strength of the welded joint such that the result may be interpreted in terms of performance of that joint in the structure. From the welding shop view-point the problem is more or less a matter of finding out the comparative effects of the various factors concerned with the making of the weld on the strength of the welded joint.

Ordnance structures as built at Watertown Arsenal are constructed with a view to produce maximum strength and resistance to shock with a minimum weight of material. The majority of the welds are of the fillet type and most of the plate used is ¼ in. or under in thickness.

For the purpose of determining the strengths of welded joints and the relative effects of details of welding procedure at Watertown Arsenal, both a tensile test and an impact tensile test are used for butt and fillet welds. Because of the fundamental differences between the two types of joints, different forms of specimens are necessary.

Another detail to be considered is the matter of X-ray examination. This method of non-destructive test has been a standard part of weld inspection procedure at Watertown Arsenal from the first use of welding as a manufacturing method. It is, therefore, desirable that all test welds be examined by this method for correlation and interpretation purposes. Also, by this procedure waste of time and money for machining and testing welds which are internally defective can be eliminated and correct welding procedure can be accurately checked before testing the welds to destruction.

Test butt welds as made at the Arsenal are usually about 9 in. long, which is a convenient length for a 10-in. X-ray film. Figure 3 illustrates the test specimens used for the tensile and impact tensile tests.

The procedure used in making the impact tensile test is illustrated in Figs. 4 to 6, inclusive. Figure 4 shows the butt weld specimen being assembled in the

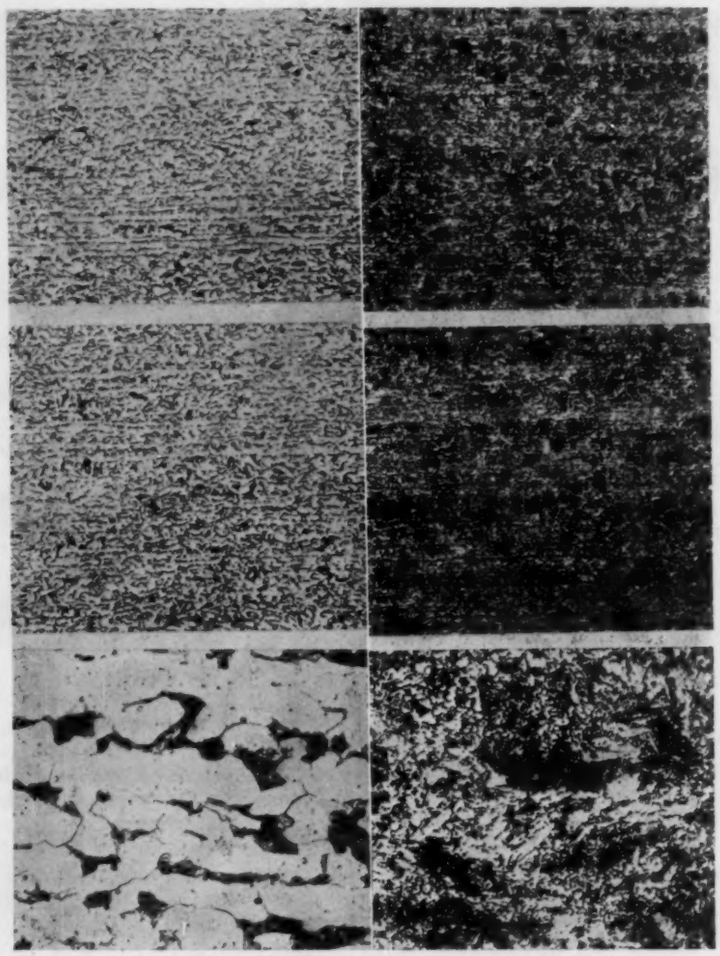


Fig. 1 Fig. 2

(Photos reduced to about ⅓ original size)

Fig. 1—Photomicrographs of Plain Carbon Steel Plate 1/4 In. Thick, 0.23% C.

Fig. 2—Photomicrographs of Structural Nickel Steel Plate 1/2 In. Thick, 0.43% C., 3 1/2% Ni

fixture which in Fig. 5 is attached to the head of the pendulum of the Charpy machine. While in this position the fixture is adjusted for alignment so that when the pendulum is released from the position shown in Fig. 6 the two ends of the tup will strike squarely on the ends of the projecting anvil horns located at the base of the machine. It is very essential that accurate alignment of the specimen and tup be secured to avoid an impact bending moment during rupture. The amount of energy required to break the specimen is measured in ft.-lb.

As it is not desired to locate the fracture arbitrarily at any particular section of the welded joint but rather to determine the impact resistance of the entire joint and the location of the weakest section, a notched bar is not used. The width of test section used for this type of specimen is more or less arbitrary and has been chosen, as shown in the illustration (Fig. 3), to be adequate for the purpose of testing structural plate up to and including 1/2 in. in thickness. The total energy capacity of this impact testing machine is about 2200 ft.-lb. With the specimen shown, structural 3 1/2% nickel steel plate 1/2-in. thick gives an impact value of about 1800 ft.-lb. For plate thicker than 1/2 in., this width of 5/8 in. must be reduced or some other change of dimension made in order to test within the capacity of the machine.

The impact values shown by plate material tested with this type of specimen are approximately as follows:

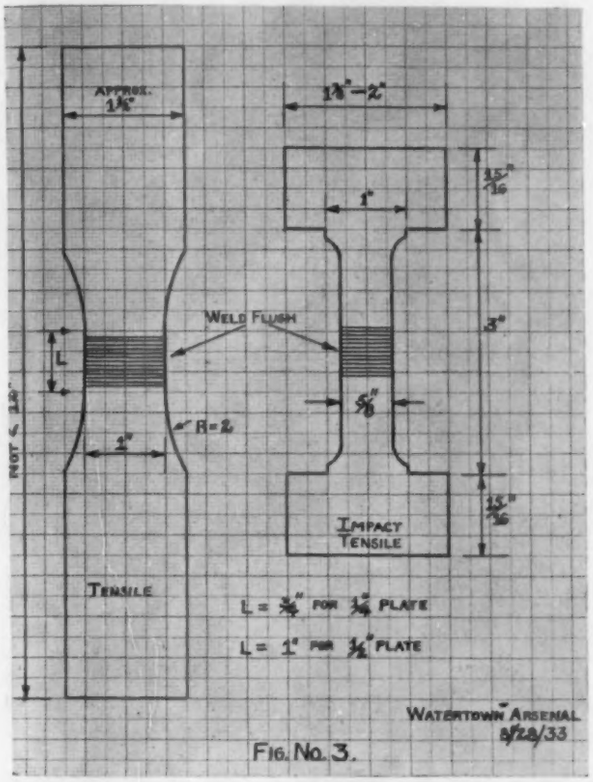
Plate Thickness, In.	Structural Carbon	Structural Nickel
1/4	700	850
1/2	1500	1800

For testing fillet welds, a different form of specimen is used as shown in Fig. 7. These test specimens are machined from a welded plate specimen of the size and shape shown in Fig. 8. Figures 9 and 10 show the tensile and impact tensile specimens, respectively, set up in the fixtures ready for test. Figure 11 shows the impact tensile specimen and fixture assembled in the testing machine.

As yet no suitable specimen has been devised for testing of fillet welds in impact parallel to the fillet and at the same time permit of a simple and understandable X-ray examination as is possible with the type of specimen illustrated. When the specimen is of such form that one or more welds are superimposed for the X-ray examination, the results are very nearly impossible to correctly interpret as regards the size and location of internal defects which may occur in the welds.

The type of fillet specimen shown has been used be-

Fig. 3—Forms of Specimen for Tensile and Impact Tensile Tests of Butt Welds



cause of the fact that most of the joints used in ordnance structures built at Watertown Arsenal and others are of that type, and the X-ray inspection of the welds presents no complications either in the making or the interpretation thereof. At present the impact test is a comparative test only and one which is more sensitive than any other to differences in weld characteristics. For this reason the test outlined may be used to test full weld sections in order to determine the relative effect of different details of welding procedure.

Figure 12 illustrates a few basic differences between welds made with bare and covered low-carbon electrodes on structural nickel plate. This same comparison would be similar for structural carbon plate, except that the welding heat used might be somewhat higher for the carbon plate and the heat-affected zones of the parent metal would be less prominent.

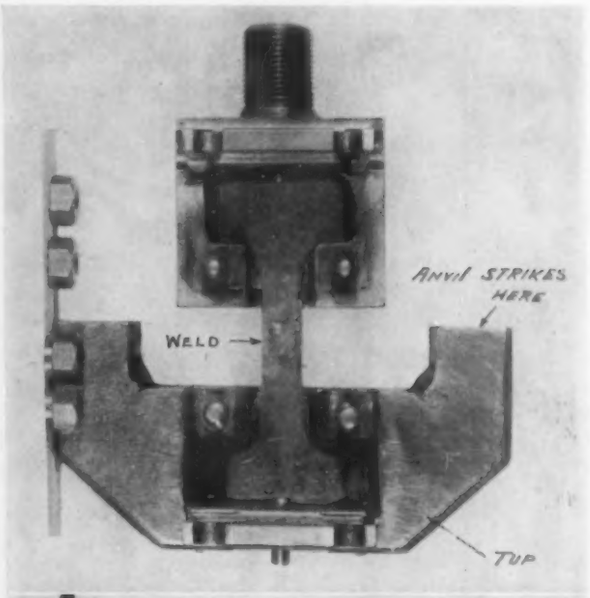
It will be noted that the contour of the single layer fillet welds are different, that of the covered electrode being more nearly as a fillet should be, and the fracture of the covered electrode weld is silky, like that of the parent metal, while the fracture of the bare electrode weld is crystalline. These characteristics have been observed before on carbon steel plate and are well known.

Figure 13 gives a general comparison of the strengths of butt welds made with bare and covered low-carbon electrodes on $^1/_4$-in. structural nickel plate. The difference in physical properties of the welds made with the two types of electrode is obvious. The effect of the 600° C. stress-relieving treatment on the physical properties, particularly impact, should be noted. The tensile strength has not changed appreciably, while the impact strength has nearly doubled as a result of the heat treatment.

The usual practice at the Arsenal for butt welds is to bevel thicknesses of $^1/_4$ in. and over at about $37^1/_2$° with a slight shoulder at the bottom, between $^1/_{32}$ and $^1/_{16}$ in. On thicknesses of $^1/_4$ in. and under a $^1/_8$-in. bare low-carbon electrode with 110–120 amperes is used, and these conditions are strictly adhered to. From $^1/_4$ in. in thickness, up to and including $^1/_2$ in., a $^5/_{32}$-in. electrode may be used with a maximum of 150 amperes. For regular production welding of nickel steel plate structures such as are built at Watertown Arsenal, these limits are not exceeded.

Structural nickel plate butt welds generally show a

Fig. 4—Assembly of Butt Weld Test Specimen and Fixtures for Impact Testing



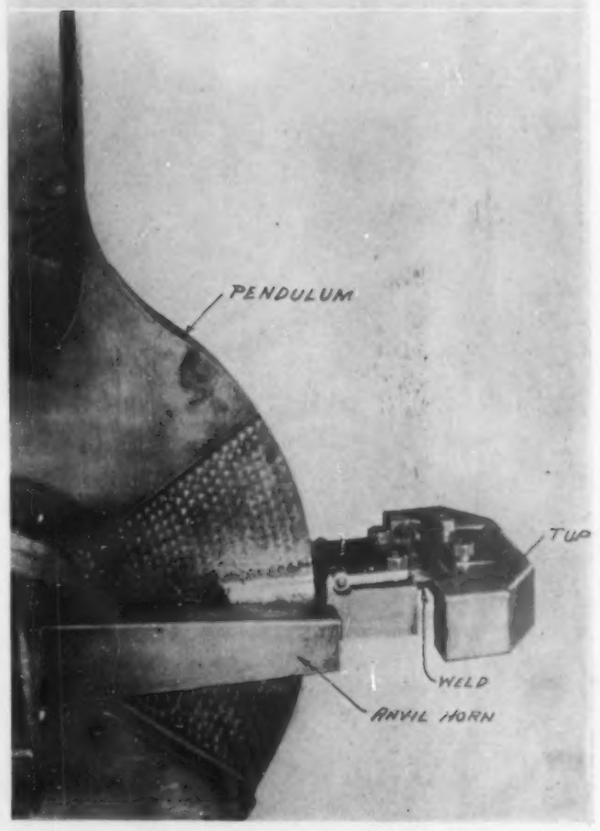


Fig. 5—Butt Weld Test Specimen in the Testing Machine Ready for Impact Testing

more porous condition with bare electrode than similar welds on structural carbon steel, and this characteristic becomes more pronounced as the amperage is increased above the limits given. With bare electrode, the porosity of the weld metal on nickel steel plate is also sensitive to arc length and rate of travel. A very short arc of, say, 15 or 16 volts will produce a porous metal, even though the current is proper for the size of electrode being used. An arc of 18–20 volts gives best results as to soundness and physical properties. An arc of 20–24 volts with bare electrode will produce a clearer X-ray picture, but the metal is brittle and low in impact. Upon examination under a low power microscope, the metal will be seen to be honeycombed with microscopic gas holes. These minute gas holes seem to occur in groups and produce a slightly smoky appearance on the X-ray film. They do not show the sharpness of outline which is produced by the larger but fewer gas holes in the weld metal deposited with the shorter arc.

Fig. 6—Starting Position for Impact Test in the Charpy Machine

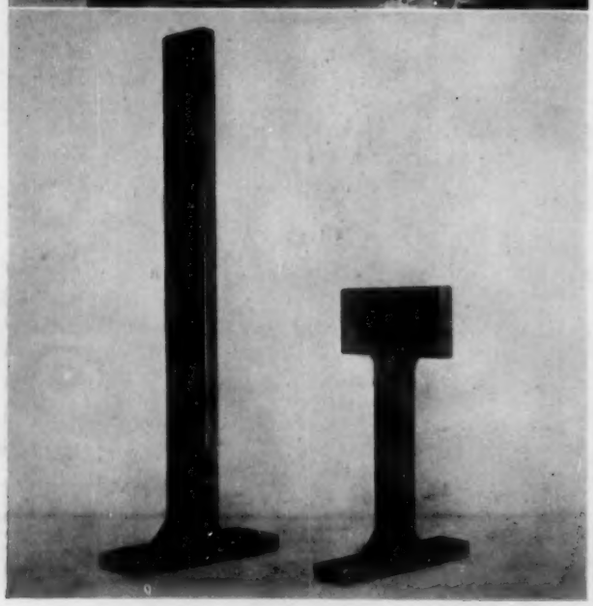


Fig. 7—Forms of Specimen for Tensile and Impact Tensile Tests of Fillet Welds

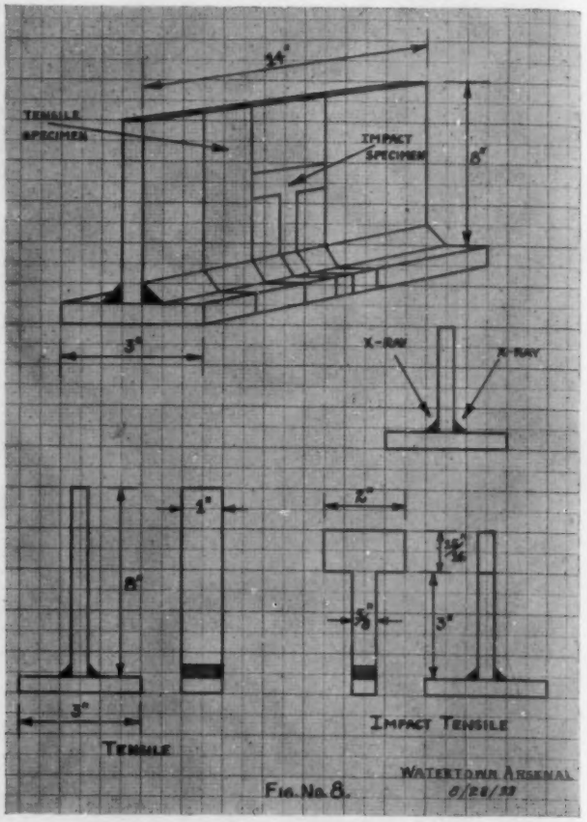
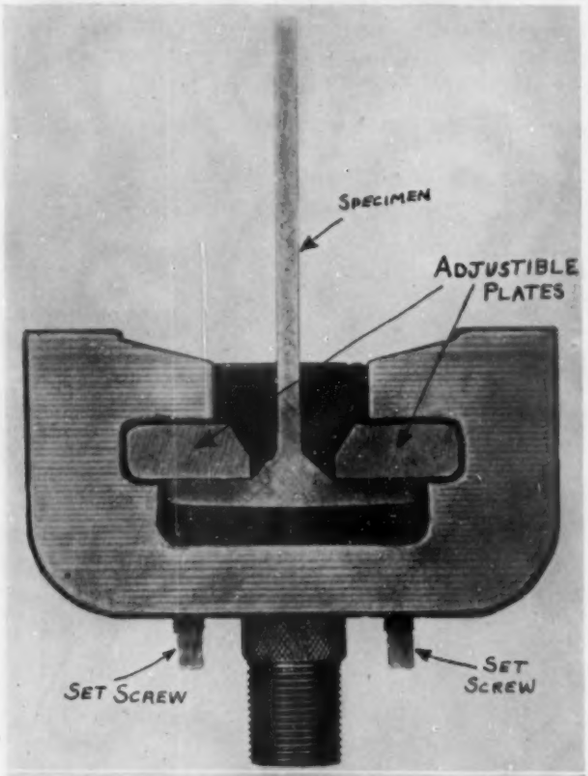


Fig. 8—Preparation of Test Specimens for Tensile and Impact Tensile Tests of Fillet Welds

Weld metal deposited from a covered electrode on structural nickel plate does not show the same sensitivity to current, arc voltage or speed of travel as with the bare electrode. The welder can produce sound welds under any usable welding conditions where he can handle the electrode properly. On structural work, the manipulation of present types of commercial covered electrodes is very exacting and costly because of the heavy slag involved.

In order to satisfactorily make a butt weld with uniform penetration of the joint, some sort of backing material is necessary. This may be a cast-iron block, strip of copper or, if the backing is to be permanently attached to the joint, a thin steel strip may be used. Where the backing is used as a chilling medium only and the weld is not fused into it, some difficulty is usually experienced with porosity in the first layer deposited which occurs where the hot metal strikes the backing metal. This porous condition is not pronounced when bare electrodes are used, but is very pronounced when covered electrodes are used. In order to remove this porous zone in the first layer deposited, a single run or bead of welded metal may be laid along the back of the joint after the weld in the beveled joint has been completed. This is designated as a seal bead and is generally a much better guarantee of uniform and thorough weld penetration than to make the weld from one side of the plate only. With covered electrodes the seal bead is always required, unless the weld is fused into a backing strip, but not necessarily so with bare electrode. The heat used in

Fig. 9—Fillet Weld Tensile Specimen with Testing Fixture Attached Ready for Test



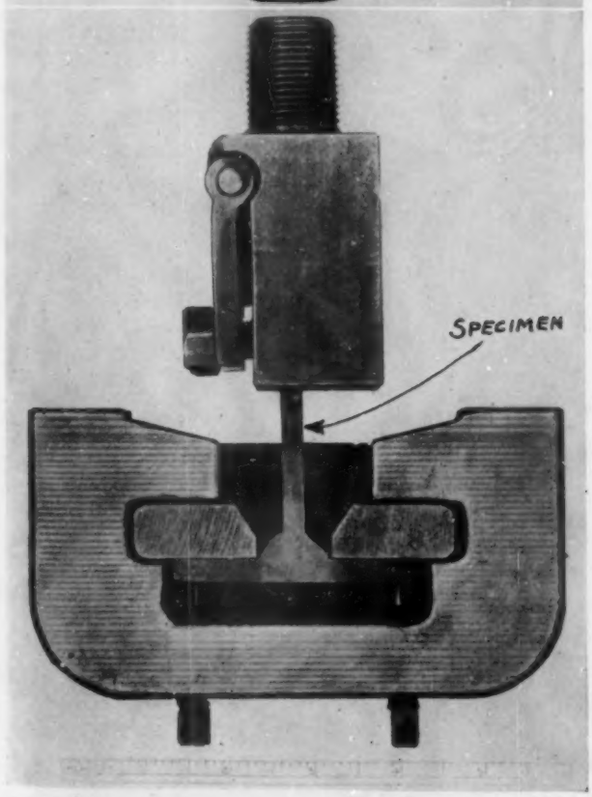


Fig. 10—Fillet Weld Impact Tensile Specimen with Testing Fixture Attached

applying the seal bead after the weld has been completed produces a heat treatment of the weld metal already deposited which improves the strength. This heat treatment effect is more prominent when covered electrode is used.

In Fig. 13 those butt welds made with the $^5/_{32}$-in. covered electrode in one layer with seal bead showed more than double the impact strength of the welds made with the $^1/_8$-in. covered electrode in two layers with seal bead, while in both cases the tensile strengths were about the same.

It should be remembered that on structural carbon plate the covered low-carbon electrode produces a tensile strength of 60/65,000 lb. per sq. in., whereas the same electrode on $^1/_4$-in. structural nickel plate develops 95/-100,000 lb. per sq. in. as shown here. This difference appears to be primarily due to the absorption of nickel from the plate metal melted when the weld is made. A chemical analysis of the weld metal from each of the two groups shows the nickel content of the welds made in one layer with a seal bead with the $^5/_{32}$-in. covered electrode to be from $2^1/_4$ to $2^1/_2$%, whereas the group made with the $^1/_8$-in. covered electrode has a nickel content of $1^3/_4$ to 2%. In both cases the carbon and manganese remain about the same, or 0.16 and 0.45%, respectively.

With the $^1/_8$-in. bare electrode the nickel content of the weld metal averages about $1^1/_4$ to $1^1/_2$%, with the carbon and manganese contents averaging 0.06 and 0.35%, respectively.

Figure 14 shows a comparison of fillet welds made with bare and covered low-carbon electrodes on $^1/_4$-in. structural nickel plate. In this type of joint the difference between the two kinds of weld metal is more noticeable. The tensile strengths for covered electrode fillets are generally higher and the impact strengths are considerably so. The characteristic fractures are shown. It is interesting to note the improvement in impact strength of the bare electrode fillets obtained by the

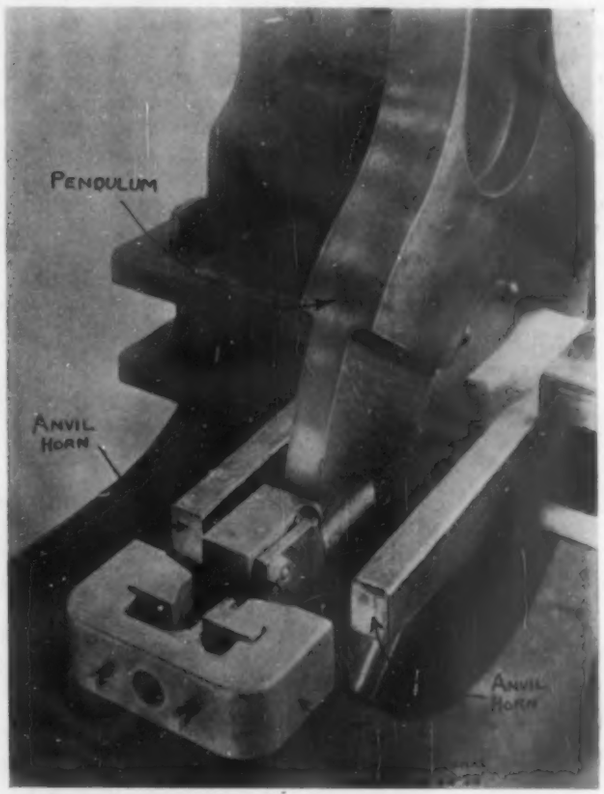


Fig. 11—Fillet Weld Impact Tensile Specimen in the Testing Machine Ready for Test

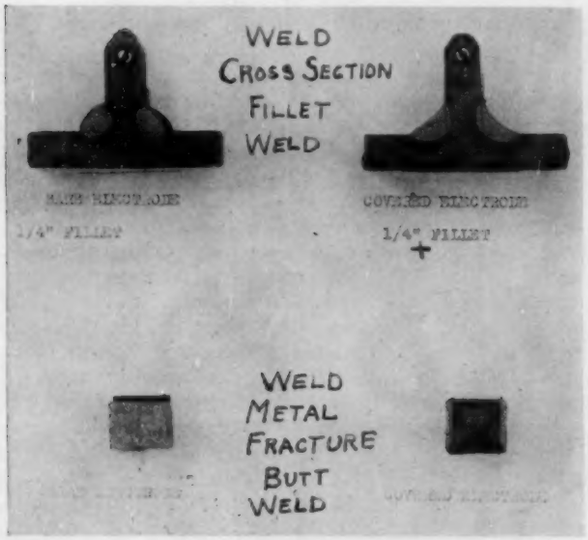


Fig. 12—Weld Sections—Bare and Covered Low-Carbon Electrodes

600° C. stress-relieving treatment. The improvement is approximately 100%, as in the case of butt welds.

A chemical analysis of the weld metal from these fillet welds shows the following averages:

	Carbon, %	Manganese, %	Nickel, %
Bare Electrode	0.05	0.25	0.9 –1.25
Covered Electrode	0.12	0.45	1.25–1.75

From these data, it is evident that on $^1/_4$-in. structural plate the tensile strength of the plate can be developed on butt and fillet welds by the use of a covered low-carbon electrode, apparently because nickel is absorbed from the plate melted in sufficient amounts to give a nickel steel weld metal with nickel uniformly diffused.

However, as the thickness of the plate increases the situation changes. The ratio of the volume of plate metal melted to the volume of metal deposited from the electrode decreases per unit of weld so that the alloy content of the weld metal is considerably below that of the plate and the strength of the weld per unit of cross-sectional area is lowered as a result.

The following chemical analysis of butt-weld metal obtained from a covered low-carbon electrode is about average for $^1/_2$-in. structural nickel ($3^1/_2$%) plate:

Carbon, %	Manganese, %	Nickel, %
0.13	0.45	1.2

This nickel content varies from about 2% at the bottom of the weld to about 1% at the top, depending on the shape of the bevel, number of layers and how the weld is made. The carbon and manganese vary only slightly.

The maximum tensile properties obtainable with commercial types of low-carbon electrodes on $^1/_2$-in. nickel steel plate are approximately as follows:

Electrode	P. L. Lb./Sq. In.	T. S. Lb./Sq. In.	Elong. 1 In., %	Red. of Area, %
		$3^1/_2$% Nickel Steel Plate		
Bare	40/45,000	65/70,000	8–10	5–10
Covered	40/45,000	75/80,000	10–15	20–25

It is evident from the above figures that the low-carbon electrode falls somewhat short of developing the strength of the $^1/_2$-in. nickel steel plate and that an alloy steel electrode of some kind is required for welding structural nickel plate over $^1/_4$ in. in thickness in order to obtain the plate strength consistently.

Fig. 13—Strengths of Butt Welds—Bare and Covered Low-Carbon Electrodes

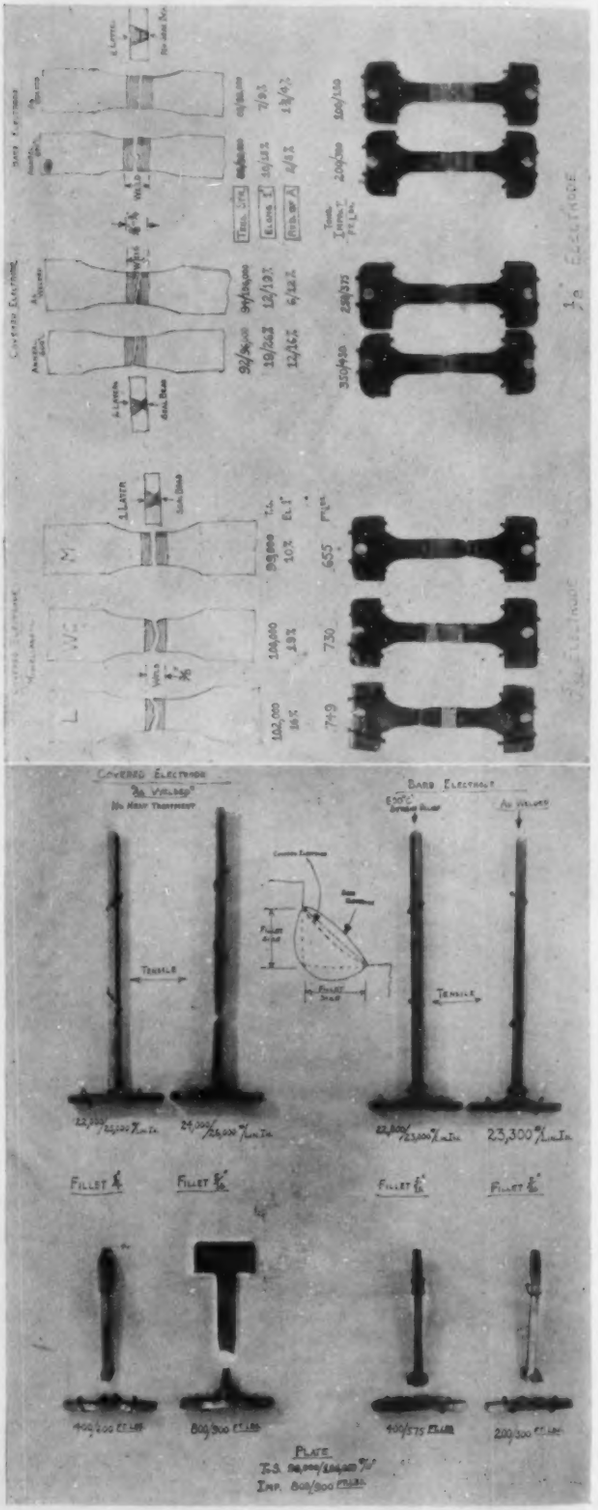
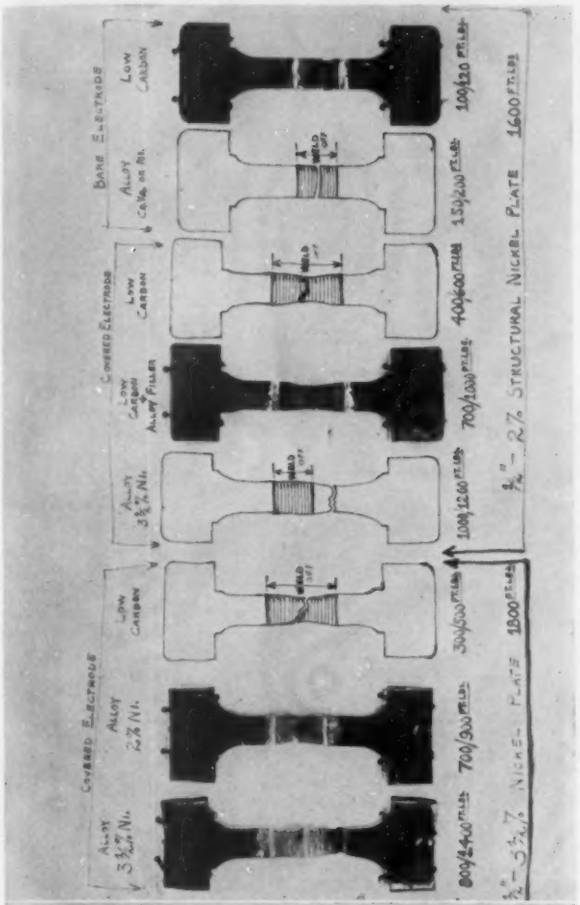


Fig. 14—Strengths of Fillet Welds—Bare and Covered Low-Carbon Electrodes

Fig. 15—Impact Tensile Test Results on Butt Welds of ½-In. Structural Nickel Plate



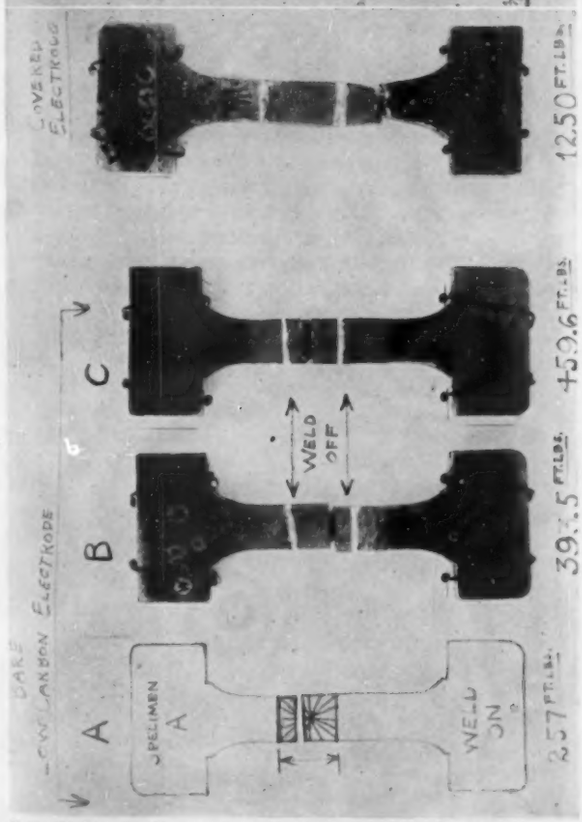


Fig. 16—Impact Tensile Test Results on Butt Welds of ½-In. Structural Carbon Plate

Just what the electrode material should be is more or less an open question and depends somewhat upon what is to be required of the weld. From our experience at Watertown Arsenal, a covered type electrode is essential to develop sound weld metal and good impact strength. It is possible that an alloy which does not contain nickel may be suitable for mechanical strength alone, whereas for low- or high-temperature properties a nickel alloy may be required.

To determine the nature of the coating required for the alloy steel electrode is a research problem which requires considerable experimentation. Tests at Watertown Arsenal with 3½% nickel steel wire covered with several commercial coatings show different effects of these coatings on the nickel steel deposit. For example, one will produce fine hair cracks in the weld metal, another coarse porosity and slag inclusions, and another very fine porosity and small shrink cracks in spite of the fact that all of the coating when used on a low-carbon steel electrode will produce Class I welds under the Pressure Vessel Code. In practically all cases the weld fractures show a considerable amount of crystallinity

It is, therefore, apparent that a suitable coating for a nickel steel electrode cannot necessarily be similar in composition and construction to that required for a low-carbon steel electrode. Whether a suitable coating should be entirely organic or inorganic, or some combination of both, cannot be definitely stated.

Experiments at Watertown Arsenal using nickel steel electrodes with commercial coatings have shown the following results on ½-in. (3½%) structural nickel steel plate:

Electrode				Weld		
Carbon, %	Nickel, %	Mn, %	P. L. Lb./Sq. In.	T. S. Lb./Sq. In.	Elong. 1 In., %	Red. of Area
0.14	3½	0.38	45/50,000	95/105,000	15/20	18/25
0.04	2	0.15	40/45,000	85/ 90,000	15/20	20/25

In both cases the weld metal was not clear of porosity, and the fractures of the test specimens showed several crystalline areas surrounded by several fine gas holes. A chemical analysis of the weld metal gave the following:

Electrode	Weld Metal Carbon, %	Nickel, %	Manganese, %
3½% Ni	0.12	3.5	0.55
2 % Ni	0.10	2.6	0.45

The carbon content of the plate was 0.43%, so it is evident that the metal from the lower carbon electrode picked up considerable carbon from the plate and possibly some from the coating itself. It has also increased in nickel content, the increase being accounted for by absorption from the plate metal melted in making the weld, as there was no nickel in the coating.

The impact test shows up differences in weld metal very prominently, as indicated in Fig. 15. In all cases the tests were made with the weld machined flush with the plate and the figures given indicate the ranges within which the impact test values for the various kinds of weld metal generally fall. The effects of coating the electrode and the addition of nickel are clearly shown.

A comparison between impact values for nickel and carbon plate welds made with low-carbon electrodes may be made by referring to Figs. 15 and 16. The use of a protective coating on the electrode has done more to increase the impact strength of the joint than the addition of nickel. This result indicates the great improvement in the resistance of the weld to dynamic

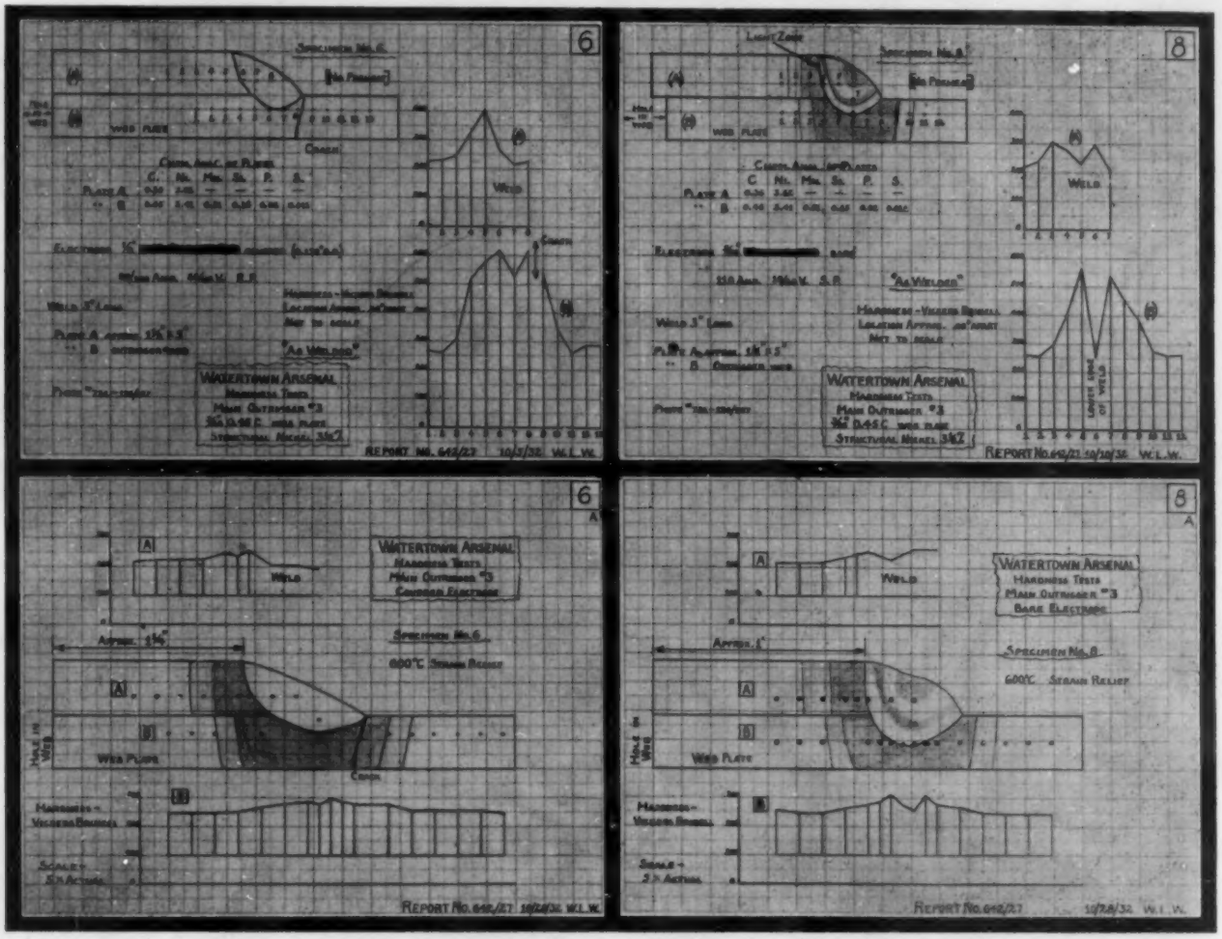


Fig. 17—Hardening Effect of Welds on Structural Nickel Plate

stresses because of the greater ductility obtained with the protective coating. There is also evident the fact that for heavy nickel steel plate welds an alloy steel electrode of some sort is required to produce suitable impact properties.

Some experiments have been made at the Arsenal with an electrode containing 1/4% molybdenum and covered with a commercial coating. This electrode gave very sound weld metal and very smooth arcing characteristics. The weld strengths obtained were approximately the same as those already given for the 2% nickel electrode.

When welding structural nickel steel plate, the heat of welding produces a greater effect on the parent metal in a narrow zone adjacent to the weld than when welding structural carbon steel because of the higher carbon content of the nickel steel plate and the presence of nickel. Exploration of the heat-affected zone adjacent to the weld with a Vickers hardness testing machine has shown hardnesses of the order of 650 to 700 Brinell on 0.45% carbon structural nickel plate. Upon examination under the microscope, zones of this hardness have shown a martensitic structure. Where the carbon content is 0.30%, the maximum hardness formed is about 450 Brinell.

These extreme hardnesses occur in the heat-affected zones of single pass welds where the temperature gradient is very steep and the rate of cooling of the metal adjacent to the weld is very rapid. The addition of succeeding layers of metal, if applied sufficiently rapidly to heat up the section around the weld and prevent quick chilling, will in most cases reduce this hardness to about 300 or 350 Vickers Brinell.

Another difficulty encountered when welding nickel steel plate of 0.35% carbon and over is that of cracking the plate immediately behind the weld through the heat-affected zone. These cracks can be prevented by preheating the plate to a low temperature before welding, but in many instances this procedure is not economically possible. The safest method is to limit the carbon content.

Figure 17 shows the hardness of the heat-affected zones of two welds on 0.45% C. nickel steel plate and the effect of a 600 C. stress-relieving treatment. The plate material is the same for both specimens but in one case covered electrode was used, while in the other, bare electrode was used. The covered electrode specimen has developed a crack through the plate. This tendency has been found to be more prominent when covered electrodes are used but may occur with either type of electrode where the mass effect of the metal being welded is sufficiently great to produce a rapid chill and the carbon content is such as to produce great air hardening properties in the material.

A stress-relieving treatment at 600° C. (1112° F.) is indispensable for welded structures of structural nickel steel plate because of the several beneficial results which it accomplishes. These have been discussed and are listed as follows:

1. Doubles the impact resistance of the weld.
2. Reduces the hardness of the heat-affected zone adjacent to the weld. This is quite essential where

machining of the plate adjacent to the welds must be done.

3. Removes the greater portion (about 90%) of the stresses in the structure set up by welding.

Also by properly loading the structure in the furnace and weighting it, certain distortions can be removed during the heat treatment without injury to the structure. This possibility is worth considering when the distortion is not local and the piece is difficult to hold properly for straightening without elaborate equipment. Straightening in the furnace in this manner does not introduce additional stresses into the structure.

In conclusion, the writer wishes to answer a question which usually occurs to anyone visiting the Arsenal Welding Shop after seeing the results obtained with commercial types of bare and covered low-carbon electrodes on laboratory tests. Bare low-carbon electrodes are still being used for at least 90% of the welding on ordnance structures. The cost of using commercial types of covered electrodes is from 50 to 100% more than bare electrodes on these structures, which are designed for the use of bare low-carbon electrodes.

We believe that for structural work a general purpose covered electrode could and should be developed which will give complete protection to the metal passing through the arc and leave no slag on the surface of the deposited metal. The arcing characteristics should desirably be similar to the bare electrode, so that the electrode can be handled in any position similarly. When such an electrode makes its appearance, structural welding, where high impact and vibration are encountered, will have taken a new impetus and structural designers can leave out a few more gusset plates by increasing allowable design stresses.

Also, a suitable alloy steel electrode is needed for welding heavy structural nickel plate to produce sound, ductile welds of high strength. Other high tensile structural steel alloys are rapidly being developed, and the welding industry cannot afford to sit back complacently in the face of this challenge to its resourcefulness and inventive genius.

In closing the writer wishes to emphasize the active interest and cooperative spirit of Col. G. F. Jenks, Commanding Officer of Watertown Arsenal, and Mr. J. F. Maguire, foreman of the erecting, structural and welding shops, in the development and improvement of welding methods as used for building steel structures. Without such interest and cooperation the work discussed would not have been possible.

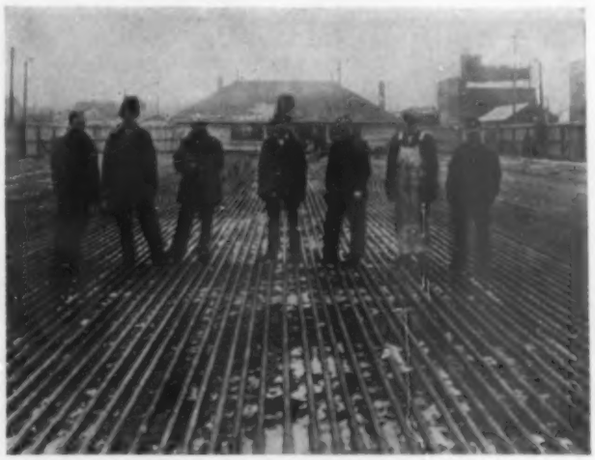
ARC WELDING LAYS 11 MILES OF PIPE IN A SKATING RINK

By **W. T. Cook**

†Mr. Cook is connected with the News Bureau of the General Electric Company.

During the construction of the new Spokane Ice Arena at Spokane, Washington, arc welding was used to lay 11 miles of $1^1/_4$-in. pipe in an area 100 by 250 ft., this figure not including 900 ft. of 8-in. main.

The work was done by the General Machinery Company of Spokane, using covered electrodes. Tests with 150 lb. of air, after completion of the welding, showed only two leaks, which were closed in about 20 min.



AN ALL-WELDED DIESEL TOWBOAT

By **R. B. Reid**

†Mr. Reid is connected with the News Bureau of the General Electric Company.

All-Welded Steel Towboat

The Equitable Equipment Company, Inc., of New Orleans, recently designed and built this all-welded steel towboat for the Stevens Brothers & Miller Hutchinson Company. The boat is for use on a lock construction project on the Tennessee River near Muscle Shoals.

The vessel has an over-all length of approximately 42 ft. 6 in., and an over-all beam of about 10 ft. 4 in. It is powered with a Cummins Model HMR, six-cylinder, four-cycle, solid injection Diesel engine which is capable of developing 85 hp. at 1200 rpm. through a two to one gear reduction.

Test of a Flat Steel-Plate Floor under Loads

By L. B. TUCKERMAN, A. H. STANG *and* W. R. OSGOOD

†Abstracted from U. S. Department of Commerce, Bureau of Standards Research Paper RP662. Part of Bureau of Standards Journal of Research, vol. 12, 1934. Messrs. L. B. Tuckerman, A. H. Stang and W. R. Osgood are members of the Bureau of Standards Staff.

IN COOPERATION with the American Institute of Steel Construction, Inc., a flat steel-plate floor was tested under loads to determine its strength and whether the floor behaved as a unit when loads were applied. The span was 18 ft. and the floor was built of 4-in. 7.7-lb. per ft. steel I-beams and steel plates, 24 in. wide and $^1/_4$ in. thick. Strain-gage and deflection readings were taken.

Continuous manual welds joining the plates to the I-beams, made by using bare metallic electrodes ($^5/_{32}$-in. diameter) and the direct-current arc-welding process, united the plates and the beams so that they behaved as a unit when loads were applied.

Purpose

The loading test of this steel-plate floor was made to determine:

1. The strength of the floor.
2. Whether the following assumptions are justified:

(*a*) The floor behaves as a unit when loads are applied, i.e., the welds joining the beams and plates neither fail nor deform permanently.

(*b*) The entire width of plate between beams may be considered as effective in computing stress and deflections.

Table 1—Normal Properties of the Battledeck Floor

Depth of I-beam	4.0 in.
Weight of I-beam	7.7 lb. per lin. ft.
Thickness of plate	0.25 in.
Weight of plate and weld	20.4 lb. per lin. ft.
Total weight of I-beam, plate and weld	28.1 lb. per lin. ft.
Average weight of floor	14.05 lb. per sq. ft.
Cross-sectional area (1 beam and 1 plate 24 in. wide)	8.21 sq. in.
Distance of the centroidal axis of the floor from the bottom of the I-beam	3.553 in.
Moment of inertia of the cross section of the floor about the centroidal axis (1 beam and 1 plate 24 in. wide)	13.32 in.^{4}
Section modulus of floor (1 beam and 1 plate 24 in. wide)	3.75 in.^{3}

Conclusions

The results of a loading test of a battledeck floor of 18-ft. span, built of 4-in. 7.7-lb. per ft. rolled steel I-beams spaced 24-in. and $^1/_4$-in. rolled steel plates indicated that:

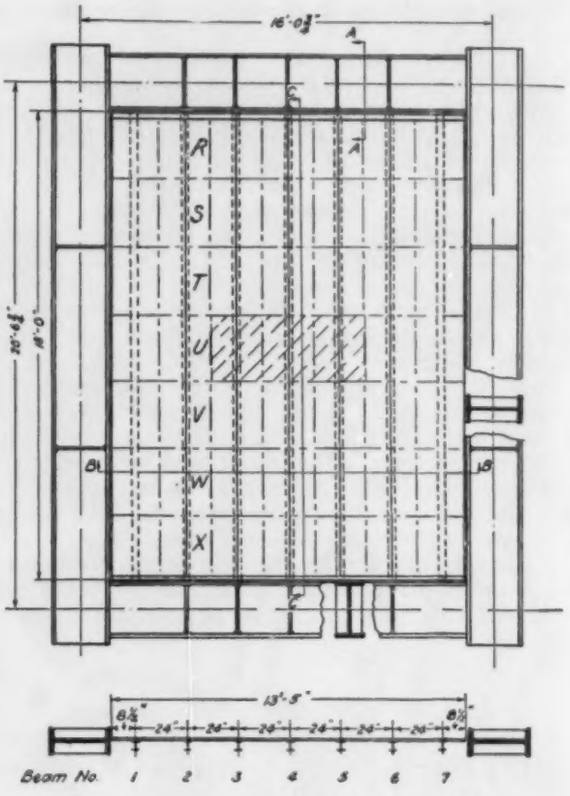


FIGURE 1.—*Battledeck floor and restraining frame.*

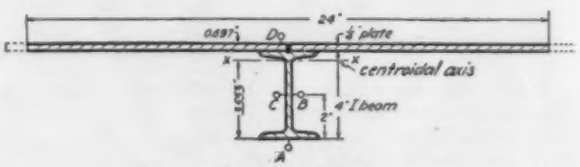


FIGURE 2.—*One beam element of the floor.*

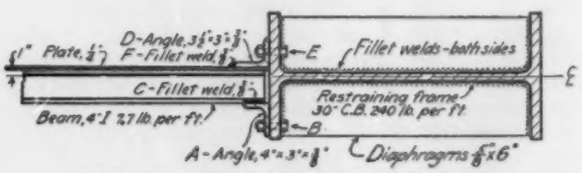


FIGURE 3.—*A longitudinal section at the end of the floor.*

1. The continuous manual welds joining the plates to the I-beams made by using bare metallic electrodes ($^1/_{32}$-in. diameter) and the direct-current arc-welding process united the plates and the beams so that they behaved as a unit when loads were applied.

2. The measured stresses and the measured deflections were in substantial agreement with values computed by the ordinary theory of beams.

3. This floor carried a load of 420 lb. per sq. ft. for $5^1/_2$ days without any indication of collapse. The deflection under this load was $3^7/_8$ in. After the load was removed the permanent deflection was $2^3/_4$ in.

4. The results of this test gave no positive indication as to the width of the plate which may be considered effective. There is a strong presumption, however, that under conditions of loading and length of span not totally unlike those of the test an effective width up to 24 in. may be assumed in designing with $^1/_4$-in. plate.

Training Welders

By **H. T. BENT**

✦Mr. Bent is Assistant Superintendent of the Newport News Shipbuilding and Dry Dock Company.

REALIZING perfectly that standard of workmanship must be much higher in naval and marine work than in any other class of work, due to hazards of the sea, this company set out some time ago to train its own welders to the high standard considered necessary. For some time the Welding School has been able to accommodate 15 students at one time, but on account of the unprecedented amount of welding on the two new Aircraft Carriers, a new school has been built which will accommodate 35 students at a time. At the present time 4 classes of 35 men each are undergoing training; the day classes, 2 in number, undergo training 4 hrs. per day for five days per week; the night classes undergo training 3 hrs. per night and attend school every other night; the average welder will, therefore, finish his training in from 4 to 7 months, depending on which class he is in. I might say that the idea of night classes is to afford men working during the day an opportunity to learn welding. This schedule will result in approximately 140 trained welders, but it is the intention at this time to train approximately 200, and additional classes will be started as fast as men in the present classes complete their course of training.

The course starts in welding simple beads in all welding positions, that is, flat, vertical and overhead, and from these simple beads develops the various welds required in shipbuilding. As welds are made, and skill builds up to the point where the student has welded two pieces of metal together, he is required to break the weld so as to see the condition inside; if these welds are porous or dirty, or contain slag inclusions, or the penetration is poor, the cause is carefully explained to the student, who thereupon continues to make welds until they are absolutely free from defect. Breaking the welds has been of the greatest importance from a psychological standpoint in training good welders, since the progressive improvement which he can see, and, after understanding, can control, gives him confidence and assures him that he is progressing. Fillet welds are the hardest of all to make, and more attention is probably paid to them in all three welding positions than to any other types of welds, and with fillet welds the foreman of the Welding Department himself examines the final specimens, with particular reference to neatness, uniformity and undercutting, after which they are broken for the inside examination. If these welds are satisfactory, the student is then ready to make his so-called control specimens, and after these are made he takes the final Government test. During the course of training every type of weld is made by the student, such as fillet welds, butt welds, corner welds, saddle butt welds, pipe welds, etc., and pipe welds are even hydraulically tested to show the student the effect of porosity and pinholes causing leaks under pressure. All training is with covered electrode; we do not use bare wire any more on any job whatsoever. All equipment and material provided for use in the Welding School is of the highest quality, for without this the student welders cannot learn to do first-class work.

When each student has made his final control specimens and proved to the Welding School personnel that he has attained the necessary skill, he takes the definite Government test and is accordingly certified to do Naval work, if this test is satisfactory, and passes requirements. The Government test consists of a definite series of welds which are tested in our Laboratory under the supervision of the office of the Superintending Constructor. The certified student welders are then given relatively simple jobs and watched very closely for a number of months until they develop into seasoned and experienced welders.

A high standard of quality welding can be maintained by definite control of welding instruction, and this, in turn, is obtained by training large groups of men particularly adapted to this work under competent instructors and supervisors who follow the training closely and, after training, follow up the practical jobs and inspect all welds. The instructors, of which we have three, are all expert welders themselves, and have been taught exactly how to impart their knowledge to the student welders. Our experience has been that at least 9 out of 10 men applying for employment as first-class welders are not nearly as good as our student welders who have just completed the course of training. I might add that in many cases difficult jobs will occur under production conditions and it has been found distinctly advantageous to remove even old and experienced welders from productive work for a sufficient time to send them to the Welding School to learn to make the particular weld that is causing trouble on the job and develop the proper technique.

As indicated, the course and the final certification is under the supervision of the Superintending Constructor, U. S. N., and only those students who can pass the rigid Government requirements are allowed to work on Navy work. We qualify all welders and actually there are none in the plant, unless he is a student welder, who has not completed his course of training, who is not eligible to work on Government work. The American Bureau of Shipping and Lloyd's Register of Shipping do not require any particular qualification or certification; these societies know, however, that all of our welders are permitted to work on Government work and are, therefore, satisfied that first-class welding is being done on work coming under their supervision.

It might be interesting to note that welding instruction is not confined to men learning welding only. A number of our supervisory people have taken the course in order to gain more knowledge in connection with welding; this group includes Staff Supervisors and Supervisors in departments other than the Welding Department. We have also trained ship's personnel as a favor to some of our customers, and have trained the personnel for the U. S. Aircraft Carrier's *Ranger* who will operate the welding sets on the ship when she is in service. Last, but not least, American Bureau surveyors stationed at this plant have taken the course.

Welding done by these certified welders embraces all phases of hull work, machinery and boilers, structural work, tanks; in fact, they are capable of doing any sort of welding that has been developed to date, bearing in mind, however, that the welding of special materials, such as aluminum, corrosion-resisting steels, etc., requires postgraduate course of instruction and additional certification. Gas welding is also taught to a limited number, and all courses include complete instruction on the use of oxygen and acetylene, heating, cutting and heavy cutting, while thermit welding is considered in the training course to a sufficient extent so that when the need arises additional men for this class of work can be quickly developed.

FROM ABROAD

The Stresses in Fusion Joints

By Professor E. G. COKER, D.Sc., M.A., F.R.S., M. I. Mech. E. (*Member of Council*), Miss R. LEVI, Ph.D., *and* R. RUSSELL, B.Sc.

†This paper abstracted from the Proceedings of The Institution of Mechanical Engineers, London. The authors are connected with University College, London.

THE use of fusion joints instead of riveted or bolted connections often leads to simplifications in the design and manufacture of machines and structures and, as a consequence, to considerable savings in weight and cost.

At the present time, however, a case for their use cannot always be made out with that strength of conviction which comes from long experience of their behavior in use, for such joints are comparatively new and untried as compared with riveted and bolted connections. An engineer may hesitate to use them and possibly decide to employ another form of joint of which he knows the best and worst. Although such an eminently safe procedure does not make for progress, there is no doubt that the caution which is being exercized in this field of activity is not entirely unreasonable.

A vast amount of evidence of the most varied kind needs to be collected and arranged for the information of engineers, and, to be really useful, it must be unprejudiced and non-partisan. A good deal of investigation has been carried out by impartial observers and corporate bodies desirous of ascertaining the facts, and there is general agreement that the subject still offers a field of inquiry and experiment.

One of these research aspects relates to the distribution of stress in a completed joint when under load, directed more particularly to ascertaining where the greatest concentration of stress takes place and its magnitude, as such joints are almost inevitably "stress raisers" at one or more places in them.

From a purely experimental point of view the subject of stress distribution in fusion joints is of great interest, for nearly all the questions which arise are comparatively new and important. Because of this it is a matter of urgency to try and find approximate solutions of such as will yield to treatment.

In a previous paper* some elementary cases were discussed on the assumption that the metal has the same physical properties throughout the joint, a condition which is not usually attained exactly, although it may be approximated in some of the welding processes now in use. Among the problems thus treated by photoelastic analysis was the case of a symmetrical butt joint for plates having symmetrically chamfered edges joined together by fusion metal filling up the V-grooves, which in the process of welding usually results in a bulge of curved form on each side. In this case it was shown that the greatest intensities of stress are at the junctions of these bulges with the flat sides of the plate, and that the local increases of stress are considerable at these

* *Proc. Inst. Mech. Engrs.*, 120, 569 (1931).

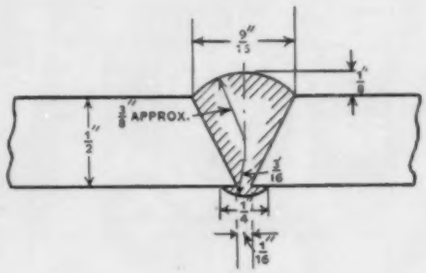


Fig. 1

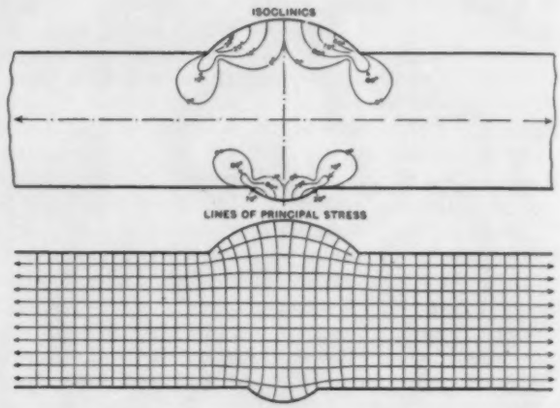


Fig. 2

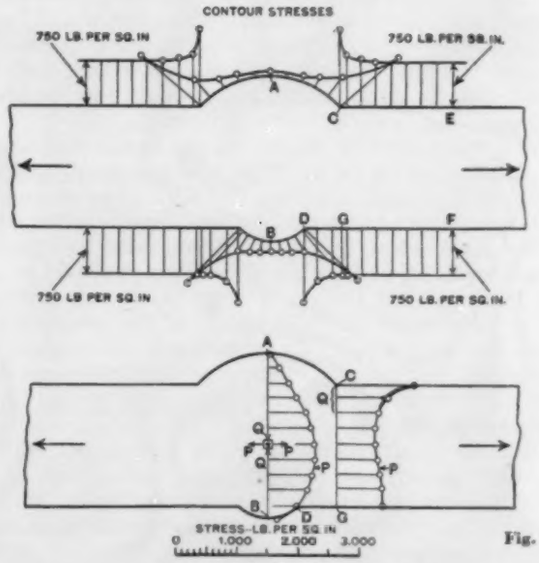


Fig. 3

Fig. 1—Section of a Fusion Joint
Fig. 2—Isoclinics and Lines of Principal Stress for the Joint of Fig. 1
Fig. 3—Stress Distributions for a Load of 138 Lb. on a Model Twice Full Size and 0.184 In. Thick

places. Because of the symmetry of this joint all these high stresses are equal at corresponding points. There are, however, a number of other butt joints now in use of an unsymmetrical type, and some of these appear to be worth examination in a similar manner. As detailed references to the processes of photoelastic analysis used are contained in the earlier paper, only such explanations need be given here as appear to be required.

One form of butt joint, used for plates of about $^1/_2$ in. in thickness, is formed by chamfering each plate from one side only, so that when they are brought together in line there is a single groove of triangular section to be filled up with fusion metal. The latter has, in general, a curved upper face, while at the apex a sealing weld is added, so that the joint has a section of the form shown

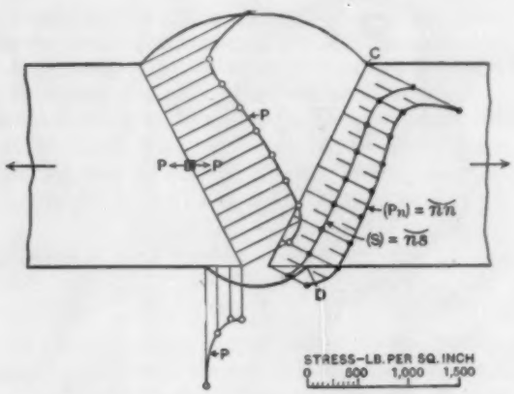


Fig. 4—Stresses on the Junction Planes for a Load of 138 Lb. on a Mode Twice Full Size and 0.184 In. Thick

in Fig. 1, in which the dimensions given are doubled in the transparent model employed for measuring the stresses.

When such a model is loaded by a central tensional pull in a field of circularly polarized light, it is at once seen that all the junctions of the curved parts of the contour with the straight sides are places of maximum stress intensity, for color bands or isochromatics are observed to cluster there. These high stresses are to be expected, for although the effect of the joint is to increase the cross section, yet it does so abruptly at the joins and, in general, when such discontinuities occur, whether by an increase or by a decrease of the cross section, an increase of stress is found due to this abrupt change.

An explanation of this is afforded when the directions of the principal stresses are traced across the joint by aid of the direction bands or isoclinics, which can be observed in plane polarized light very easily, and especially so when the stress intensity is small. These isoclinics are shown in the upper part of Fig. 2 with the directions of stress marked on them, as observed in a polariscope, from which is drawn the lower diagram of the directions of the stresses throughout the joint and into each plate where they become parallel to the contours.

As will be observed in the latter figure the abrupt change of section causes bends in the lines of stress passing through the joint, which are more and more pronounced as a contour is approached. It is this change in direction at the discontinuities which is associated with the local increase of stress whichever way the bend takes place.

The manner in which the stress intensities change along the contours is readily measured by comparing the isochromatics at the edges with the colors observed in a simple tension member by matching in the usual manner and, in this case, this has been carried out for a uniform tension stress of 750 lb. per sq. in. in the plates to be joined.

As will be seen from the upper diagram of Fig. 3 where these measurements are plotted perpendicularly to the contours at the places where they are made, the local increases of stress at the discontinuities die away very rapidly, but at the abrupt changes of section along the upper side they mount to an intensity of 1280 lb. per sq. in., an increase of 71 per cent, while at the ends of the seal weld the stress is 1200 lb. per sq. in., which is less than might perhaps be expected if the abruptness of the change of contour only is considered, but is understandable when it is noted that a considerable increase of section has now taken place.

The lower diagram of Fig. 3 shows the distribution found at the central cross section AB, and this is of interest because the normal principal stress P is very small at and near the ends. It never rises much above the average stress of 750 lb. per sq. in., while the cross stress Q is too small everywhere to be measured with accuracy. A graphical integration of the stress diagram shows that the applied tensional load is accounted for within 1 per cent, in this case in excess.

At a cross section, CG, passing through an upper discontinuity a small cross stress, Q, is found near C where the longitudinal stress P changes rapidly in magnitude, but the latter soon settles down at the lower part of the section to a nearly uniform value of 750 lb. per sq. in. A graphical integration of the stress distribution at this

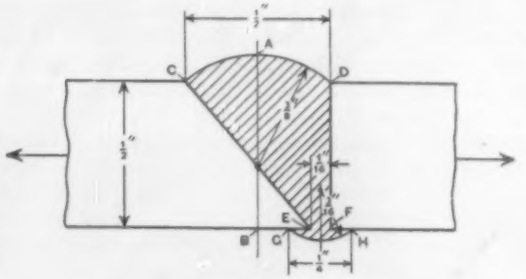


Fig. 5

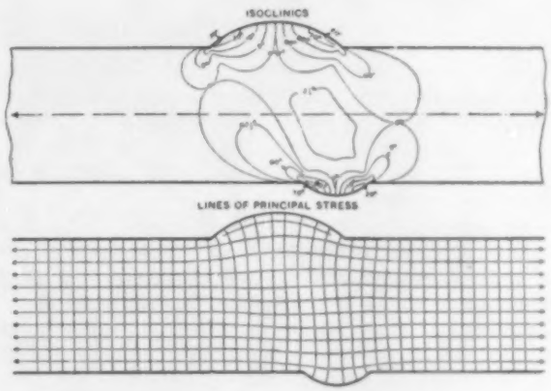
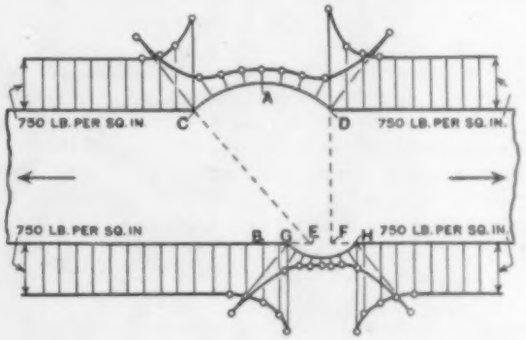


Fig. 6



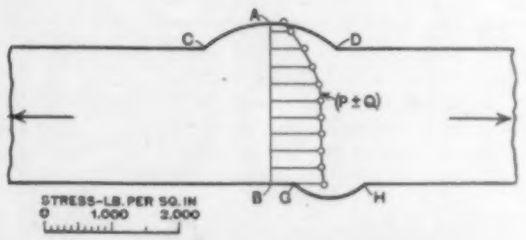


Fig. 7

Fig. 5—Section of a Fusion Joint

Fig. 6—Isoclinics and Lines of Principal Stress for the Joint of Fig. 5

Fig. 7—Stress Distribution for a Load of 138 Lb. on a Model Twice Full Size and 0.184 In. Thick

cross section shows that 97 per cent of the load is accounted for.

The most important sections to consider, however, are the inclined junction planes, since the stress along these is of more vital importance. They prove to be of a simple character, for, as Figs. 2 and 3 indicate, the distribution is almost entirely a simple stress in a direction parallel, or nearly so, to the edges of the plate, and therefore inclined at an angle of about 63 deg. to the section plane. This was verified by measuring both the sums of the principal stresses P and Q $(P + Q)$ and the differences $(P - Q)$ in the usual manner, and these values proved to be practically identical.

There are, naturally, considerable variations of stress close to the ends of each junction plane, as the measured values of Fig. 4 show, but it is of interest to note that apart from these end variations the distribution is otherwise fairly uniform. Hence, both the normal stress $\widetilde{nn}$ and the shear stress $\widetilde{sn}$ must be of a very similar type, as the observations of Fig. 4 show.

A graphical integration along these planes shows that the applied load transmitted across them is accounted for within 1 per cent, in this case in excess. It is also worth noting here that along the joint formed by the sealing weld there is a considerable stress which increases toward the outer ends.

Another joint of the same type is shown in Fig. 5 of an even less symmetrical character, although often used for the same range in thickness of plate since it only needs one chamfered edge. The dimensions are one-half those of the transparent model employed, while the various section planes examined are marked for future reference. Like the former joint the maximum stresses occur at the junctions of the curved boundaries with the straight sides.

The arrangement of isochromatics shows that somewhat different stress intensities may be expected at the ends of both the upper and lower bulges. In the upper one the stress intensity is greater on the right and in the lower at the left-hand end. The effects of these discontinuities on the directions of stress are shown in Fig. 6 by a somewhat skewed pattern of isoclinics not easy to interpret until transformed into lines of principal stress. The latter show that a certain amount of distortion of the rectangular network in the solid plates is produced in the joint, although not very much at points well removed from the discontinuities. Along the contours of this joint the stresses are easily measured by the aid of a comparator bar, and these, plotted in Fig 7, show that the maximum stress occurs at D with an intensity of 1450 lb. per sq. in. or very nearly double that in a plate, well away from the joint, while at C it is 1350 lb. per sq. in. At the outer points G and H of the sealing weld practically equal stresses of 1300 lb. per sq. in. are found.

When a cross section, AB, is examined through the central point of the upper bulge, it is found that the stress at the upper end is quite small as in the earlier case, while the distribution is practically a simple normal stress, P, throughout, with a maximum value at the lower end point B of 800 lb. per sq. in.

An integration of the stress area of this diagram shows that the stress is overestimated by 4 per cent. This margin is probably due to the presence of a very small cross stress distribution which the measurements do not reveal.

On the principal jointing planes CE and DF, Fig. 8, very similar distributions of principal stress are found to those of the former example, but owing to their different inclinations to the joints on which they act their effects are quite unlike. For example, on the plane CE, the principal stress P is in a direction very nearly parallel to the edges of the solid plate at all points and therefore inclined at a considerable angle to the section, while the minor principal stress Q is small and is a tension near C and a compression near E.

As a consequence there is stress $\widetilde{nn}$ normal to the joint and shear stress $\widetilde{ns}$, both of which are of about the same numerical value for a considerable length of the joint and do not differ very greatly at the ends, as is seen in the left-hand diagram of Fig. 8. In this diagram the measurements of $(P + Q)$ are plotted, together with the computations of normal stress $\widetilde{nn}$ and shear stress $\widetilde{ns}$ made from them by aid of the usual formulae.

$$\widetilde{nn} = P \cos^2\theta_P + Q \sin^2 \theta_P$$

$$\widetilde{ns} = {}^1/_2(P - Q) \sin 2\theta_P$$

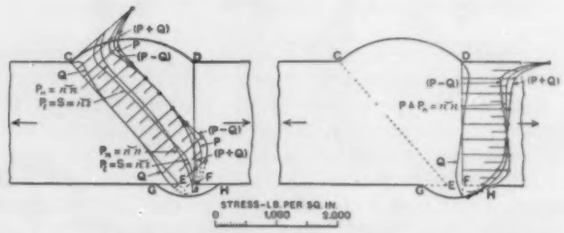


Fig. 8—Stresses on the Junction Planes for a Load of 138 Lb. on a Model Twice Full Size and 0.184 In. Thick

At the other joint DF the principal stress P is practically normal to the section everywhere, so that $\theta_P = 0$ and therefore $\widetilde{nn} = P$ and $\widetilde{ns} = 0$ very nearly. Apart from a small cross stress, Q, the joint is therefore subjected to the action of a normal and variable tension not differing much in intensity from P.

A graphical integration shows that the stress intensities of Fig. 8 account for the total load borne by each joint within 2 per cent in each case and both in excess.

Double Butt Strap Fusion Joints.—The stress distribution in one example of a double butt strap joint, with the usual triangular fillets, has already been worked out by photoelastic means and is described in a previous paper.* Two interesting variations of the above cases have, apparently, not yet received attention. These arise when the main plates are connected to the straps (1) by triangular fillets of lesser height than the butt straps, and (2) by fillets of quadrantal form with curved outer contours formed by circular arcs struck from a centre at the apex of the angle to be filled up, and with a radius less than the thickness of the butt strap used.

It is probable that the influence of the length of the butt straps does not change the distributions at the fusion joints very much unless this dimension is very small. Some liberty can, therefore, be taken in the design of a model joint by limiting the length for convenience of experimental work in the manner shown in Fig. 9. It is there seen that the straps are rather short and that both the above types of joints are embodied in one model in the manner shown in this figure, the left-hand joints having curved contours with a radius of three-quarters of the thickness of the straps, while the corresponding joints on the right are of the usual triangular type with lessened sides to correspond. A strip of transparent material with this contour then affords the re-

* Loc. cit.

quired model, if slits are provided and filled up with loose strips to give the necessary contact pressures between the plates when under load. This model is shown in the lower portion of the diagram.

When loaded by an axial pull in a field of circularly polarized light, Fig. 10, these two forms of joints are seen to have very little difference in their effects at the inner angles, while at the outer contour and at the joins with the cover plates the stresses are only of small intensity. The principal differences are seen to occur at the outer ends of the horizontal jointing planes where the right-angled bends cause high stresses at these angles as compared with those with angles of 135 deg. There are also some differences of internal stress distribution in the plates. Another feature of interest is that parts of the inner ends of the plates adjacent to the joints are also under some stress.

Some further interesting features of these joints are revealed by the isoclinics shown in Fig. 11, where it will be seen that the want of symmetry at opposite ends shows itself by corresponding variations from symmetry of the zero isoclinics at the central cross section. These, however, are not so marked as to be likely to invalidate the comparison desired.

A peculiarity worthy of note is the occurrence of isoclinics between the slits near the jointed parts of the two main plates where they form inwardly projecting tongues with free adjacent ends. These indications of stress arise, mainly, through a lateral contraction in the plane of the joint due to the central pull which causes the filling strips to exert a variable pressure on these tongues here, and in an actual joint causes a pressure between the contacting surfaces.

As is to be expected, there is a considerable complexity and also a dissimilarity of pattern in the jointing areas of each end, but the directions of principal stress are not difficult to determine, and, as shown in the lower diagram, the effects of the curved and straight contours at opposite ends have somewhat marked directional effects for a long distance into the butt straps. Despite these differences of stress direction the intensities of stress at corresponding points of the jointing planes are very much alike, as the measurements of Figs. 12 and 13 show, although there are some differences of intensity which call for remark.

Consider first the horizontal jointing planes, Fig. 12, which are under the action of principal stresses along their whole length, of which the P set has very small inclinations to the section planes, and the Q set large ones. We find that the former are of greatest intensity at the outer ends of the joints, and commence to diminish very quickly in value and afterward move slowly to a zero value at the internal end, while the Q set shows corresponding characteristics in the reverse order. The principal difference between the stress systems on the two sets of planes is a higher value of the P stress, 800 lb. per sq. in. at the point B of the curved fillet as compared with the corresponding value of 670 lb. per sq. in. at H for the right-hand end. This is the natural result of the differences in the shapes of the discontinuities at corresponding points. In one there is a right-angled corner necessitating a much greater bend of the stress lines than in the other, where the possible angular change can only be half as great.

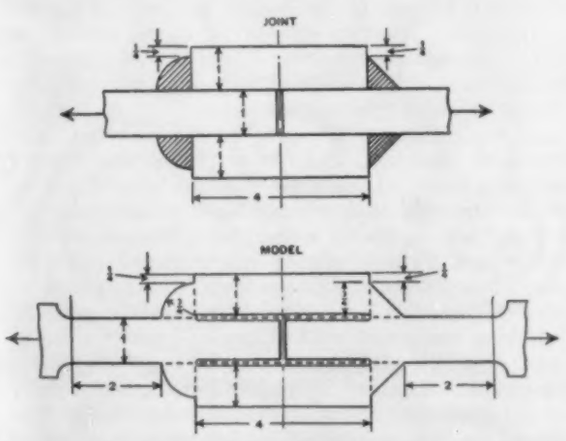


Fig. 9—Double Butt Strap Fusion Joint and a Corresponding Transparent Model

At the inner ends of the section planes where the local discontinuities are of exactly the same character, the Q stress intensities are much more nearly equal, for at point L of the left-hand joint we find a stress of 640 lb. per sq. in., and at the corresponding point M of the other joint a stress intensity of 690 lb. per sq. in. This small difference is presumably due to the different shapes of the external contours.

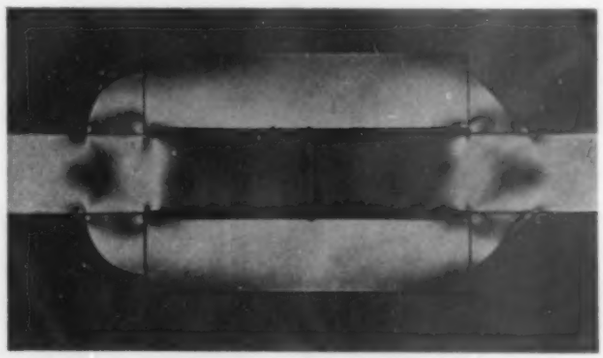


Fig. 10—Transparent Model of Fig. 9 Viewed in Circularly Polarized Light

Turning now to the distributions on the vertical jointing planes, Fig. 13, the similarity is of an even more marked character with both principal stresses reaching their maximum values at or near the inner ends of each joint and differing very little in intensity for either end. It is, however, to be noted that the principal stresses are obliquely directed across the jointing planes in a manner depending upon the type of joint, and therefore at different inclinations as shown in Fig. 11. The distributions of normal stress and shear stress will, therefore, show a much greater divergence from similarity than the principal stress intensities indicate.

An important matter to be borne in mind, when considering the stress distributions along the jointing planes, is that the effect of the rounded ends of the slits of the model is to diminish the local stresses there very much as compared with those in an actual joint where the shape of the discontinuities approximates to a straight line crack.

These experiments also show that for a tension joint of this kind there is no gain in building up a joint with a contour of curved form, since the material added beyond the line BC carries very little stress, while the right-angle at B is a positive disadvantage.

Single Strap Butt Joints.—If one of the straps is removed from this form of joint a very unfavorable stress distribution arises owing to the want of symmetry with reference to the line of the load, Fig. 14*a*, for now there is, in addition to the direct load F, a bending moment, Fl, to transmit through the strap, which causes very high stress at the jointing planes and more particularly so

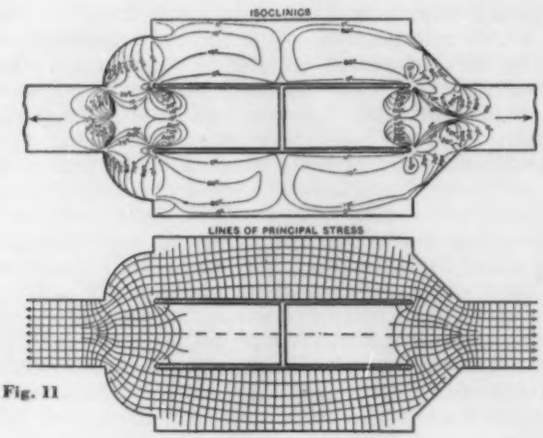


Fig. 11

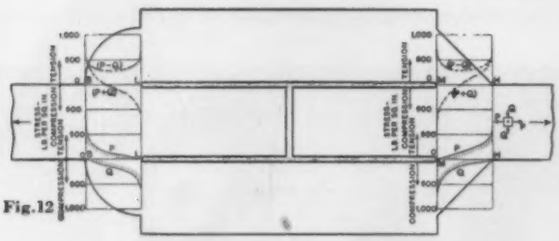


Fig. 12

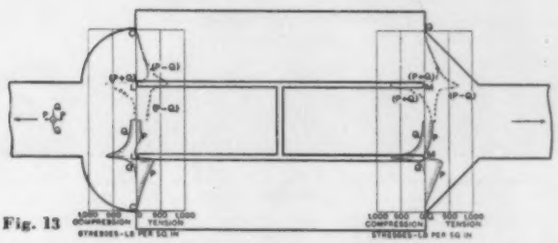


Fig. 13

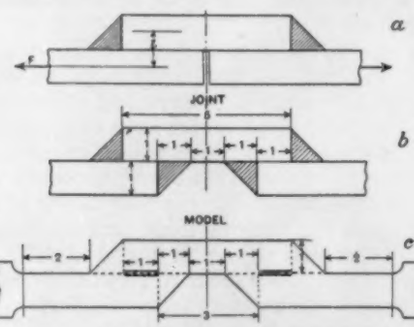


Fig. 14

Fig. 11—Isoclinics and Lines of Principal Stress for the Joint of Fig. 9
Figs. 12 and 13—Internal Stress Distribution for the Joint of Fig. 9 for a Load of 38 Lb. on a Model 0.190 In. Thick
Fig. 14—Diagrams of Single Strap Joints

at and near the internal angles. An analysis of this joint was described in the discussion of a paper by L. W. Schuster.*

A better design is produced by the addition of two further joints connecting the inner ends of the main plates to the strap, as shown in Fig. 14*b*, thereby giving an arrangement which knits the plates to the strap in a more effective manner and provides additional area for the transmission of the load across the joint. There are now two directions of approach through each end around the contact planes, which form barriers against the transmission of stress across them. A model of the joint takes the simple form shown in Fig. 14*c* in which the contact surfaces are replaced by slits filled up with loose strips as described earlier.

When this loaded model is viewed in a beam of circularly polarized light, Fig. 15, it is seen that the change in the design has produced great alterations in the stress system, for now the most direct path for the lines of stress is along the main plates and through the lower joints, with the result that the outer joints and the ends of the strap are only lightly stressed in comparison with the inner joints and the central part of the strap.

The experimental data obtained from the isoclinics and lines of principal stress, Fig. 16, show that the horizontal lines of principal stress, developed at the outer ends of the plates by the applied load, endeavor to pass across the joint by the shortest paths available, and if all these lines were continued across the joint the lower diagram of Fig. 16 would show great concentrations in the neighborhood of the edge F_1F_2, and particularly so at its end points where maximum stress intensity is observed. The complete diagram indicates the manner in which a balance of stress is effected by the pulls and pushes called into play by the applied load.

The chief matters of interest in this joint are that the stress distributions along the jointing planes of the outer fillets are of small intensity, and it is only at the inner ends of the horizontal planes of the adjacent pair that the stress intensities are very large, as is indicated by the contour stresses of Fig. 17, where a uniform intensity of stress in the plates of 267 lb. per sq. in. causes an extremely high local stress at the points F_1 and F_2 of

Fig. 15—Transparent Model of Fig. 14 Viewed in Circularly Polarized Light

2890 lb. per sq. in., an increase of over 1000 per cent. This stress diminishes very rapidly along the inclined contours F_1G_1 and F_2G_2, but always remains considerable along F_1F_2 with a minimum value at the central point E of 1810 lb. per sq. in.

Along the upper contour of the strap there is a compression stress throughout with a central maximum intensity of 1280 lb. per sq. in., while at the central cross section DE it is evident, from considerations of symmetry, that the stress is normal to the section accompanied possibly by cross stress, since the disposition of the lines of stress in Fig. 16 indicates this as likely. If, however, this cross stress exists it must be of very small intensity, for an exploration along this section shows that the sum $(P + Q)$ and the difference $(P - Q)$ of the principal stresses are nearly identical. Moreover, their distribution is practically linear as the lower diagram shows, indicating that the stress intensity on this plane may possibly be calculated on the simple assumptions that at the section DE this part of the joint may be considered as a straight beam under simple tension and bending moment. If this is correct it is easy to show that the stress at E should be a tension of 1867 lb. per sq. in. and a compression at D of 1334 lb. per sq. in., both greater than the actual values obtained by about 3 per cent in the first case and 4 per cent in the second, whereas the integrated value of the stress area shows an average defect of 2 per cent. This latter error is the more probable, for

* *Proc. Inst. Mech. Engrs.*, **I**, 407 (1930.)

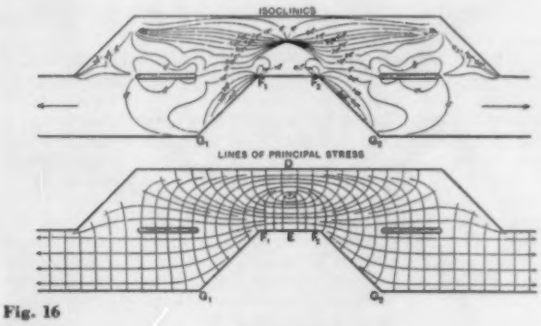


Fig. 16

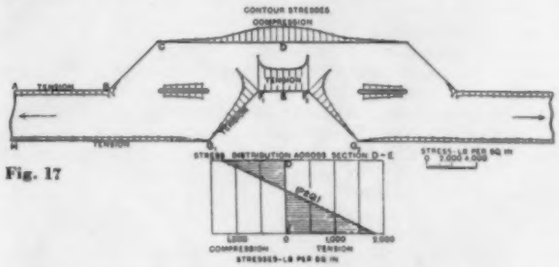


Fig. 17

Fig. 16—Isoclinics and Lines of Principal Stress for the Joint of Fig. 14
Fig. 17—Stress Distributions for the Joint of Fig. 14 for a Load of 38 Lb. on a Model 0.190 In. Thick

the assumptions of the calculations do not take into account the fact that the central section *DE* is slightly displaced toward the line of load by strain, and therefore the bending moment is overestimated in the calculations.

In conclusion the authors desire to express their thanks to The Institution of Mechanical Engineers and to the Department of Scientific and Industrial Research for the help afforded in this investigation.

COMMUNICATIONS

Discussion of Paper on Electric Arc Welding under Water

By CYRIL D. JENSEN

†The paper on "Electric Arc Welding under Water" by Professor K. Hrenoff & Eng. M. Livshitz of Moscow, was published in the April 1934 issue of the Journal. Cyril D. Jensen is Asst. Prof. of Civil Engineering, Lehigh University.

ACCORDING to the statements of the authors they were unaware of the report on Under-Water Welding, by Professors Hibshman, Harvey and myself which came out in the October 1933 JOURNAL OF THE AMERICAN WELDING SOCIETY. This report by Professor Hrenoff and Eng. Livshitz is interesting in that it verifies our work, except for the strength tests, and because it indicates there is a real activity to master the art of under-water welding.

It is unfortunate that these experimenters did not take time to place a glass plate in the side of their steel tank before making their tension specimens so that welding operations could have been viewed from the side. I am certain it would have increased materially their ultimate strengths. Herewith are the results they obtained, transposed into English units.

Specimen No.	Approximate Thickness of Material, Inches	Length, Inches	F. W., Inches	Breaking Load, Lb.	Stress, Lb. per Sq. In.
1	1/8	2	0.08	7,850	24,900
2	1/4	2	0.16	13,520	21,800
3	1/4	2	0.136	20,750	39,200

It is to be observed that their welds were small and the stresses erratic. Because of the consistently high tensile stresses obtained in our work we make no pretense to having perfected the art. Our advantage, we feel, lay entirely in the matter of better vision. Among the problems still to be mastered are vision, arc blow, the making of neat-looking fillet welds and vertical welding.

Mistake in Testing Proves Quality of Weld Metal

By A. F. DAVIS

†Mr. Davis is Vice-President of The Lincoln Electric Company.

WHILE testing this arc-welded brewery tank at the Kane Boiler Works, Galveston, Texas, 125-lb. pressure was applied instead of the required 25 lb. The tank bulged, grew 1 ft. longer!

Inspection revealed that despite five times normal testing pressure every weld was sound. Not a single leak or fracture developed. The tank was built by the Kane Boiler Works using the shielded-arc process with covered electrodes.

CURRENT WELDING LITERATURE

Automobile Body Manufacture. Electricity Dominates Design of Auto Body Welder, H. B. Veith. Machine Design (Feb. 1934), vol. 6, no. 2, pp. 24–27.

Barrels. Solid Stainless Steel Drum Has Flash Welded Seam. Steel (Mar. 26, 1934), vol. 94, no. 13, p. 36.

Boiler Manufacture. Development of Welding as Applied to Boiler Drums and Steam Receivers—I, II and III, C. H. Davy. Steam Engr. (Feb. 1934), vol. 3, no. 5, pp. 198–201; (Mar.), no. 6, pp. 253–255; and (Apr.), no. 7, pp. 291–294. See also Welding J. (Jan. 1934), vol. 31, no. 364, pp. 6–14; and (Feb.), no. 365, pp. 38–47.

Boilers. Significance of Welding Tests, L. R. Leveen. Boiler Maker & Plate Fabricator (Apr. 1934), vol. 34, no. 4, pp. 102–103.

Boulder Dam Project. Steel Headers and Penstocks for Hoover Dam Mark Notable Advance in Engineering Construction, R. G. Skerrett. Western Construction News & Highways Builder (Mar. 1934), vol. 9, no. 3, pp. 79–83.

Bridge Construction. Caisson Welding on World's Largest Bridge, J. H. Dodge. Welding Engr. (Feb. 1934), vol. 19, no. 2, pp. 17–18.

Bridges, Steel. Reconstruction of Bridge, C. M. Vetter. Welding (Feb. 1934), vol. 5, no. 2, pp. 53–54.

Car Building. Welding in Construction of Passenger Coaches, O. Bondy. Ry. Engr. (Apr. 1934), vol. 55, no. 4, pp. 120–123.

Copper Welding. Arc Welding Copper Vessels for Largest Distillery, W. J. Chaffee. Welding (Mar. 1934), vol. 5, no. 3, pp. 97–98.

Dairy Equipment of Stainless Steel, F. L. Prentiss. Iron Age (Apr. 5, 1934), vol. 133, no. 14, pp. 20–23 and 82.

Diesel Engines. Welded Joints, E. Chapman. Mill & Factory (Feb. 1934), vol. 14, no. 2, pp. 39–41, 72 and 74.

Electric Welding. Procedure Control of Electric Welding, J. E. Kennard. Instn. Production Engrs.—J. (Mar. 1934), vol. 13, no. 3, pp. 160–165; (discussion), 166–168.

Electric Welding, Arc. Arc Welded Fusion Metal—III and IV, R. Notvest. Welding (Feb. 1934), vol. 5, no. 2, pp. 59–64; and (Mar.), no. 3, pp. 99–102 and 108.

Electric-Arc Welding Process, W. Barr. Iron & Coal Trades Rev. (Apr. 6, 1934), vol. 128, no. 3449, pp. 563–564.

Electric Welding, Arc. Lesson in Arc Welding. Boiler Maker & Plate Fabricator (Apr. 1934), vol. 34, no. 4, pp. 106–108. Continuation of lessons.

Electric Welding, Arc. Fusion Welding, W. D. Walcott Hydro-Elec. Power Commission Ontario—Bul. (Apr. 1934), vol. 21, no. 4, pp. 143–150.

Electric Welding Machines. Portable Electric Welding Sets. Engineer (Apr. 27, 1934), vol. 157, no. 4085, p. 438; see also Engineering (Apr. 27, 1934), vol. 137, no. 3563, p. 502.

Electric Welding, Resistance. Types of Resistance Welds and How They Are Used, F. S. Stickney. Product Eng. (May 1934), vol. 5, no. 5, pp. 162–165.

Gas Holders. Erecting All-Welded Gas-Holder, T. F. Bright. Welding Engr. (Apr. 1934), vol. 19, no. 4, pp. 20–24.

Hard-Facing, Inserts and Plating Satisfy Hardness Requirements, A. F. Clark. Machine Design (May 1934), vol. 6, no. 5, pp. 27–30.

Houses, Steel. Fabrication of Metal Houses. Welding (Mar. 1934), vol. 5, no. 3, pp. 113–114 and 118. Units are factory built by arc and resistance welding, door and window openings are cut with oxyacetylene torch, and units are erected in field by welding.

Inspection of Welded Work and Training of Welding Inspectors, W. D. Halsey. Boiler Maker & Plate Fabricator (Mar. 1934), vol. 34, no. 3, pp. 70–73.

Jigs and Fixtures. Reducing Tool Costs with Arc-Welded Construction, L. E. Fuller. Machy. (N. Y.) (Apr. 1934), vol. 4, no. 8, pp. 478–479. Examples showing flexibility of design obtainable by arc welding.

Locomotives. Welding in Construction of Locomotive and Railcars, O. Bondy. Ry. Engr. (May 1934), vol. 55, no. 5, pp. 144–147. Recent developments in Germany.

Machinery. Welding in Plant Rehabilitation, G. Hettrick Welding Engr. (Feb. 1934), vol. 19, no. 2, pp. 19–22.

Machinery Manufacture. Welding and Steel Industry, A. E. Gibson. Iron & Steel Engr. (Mar. 1934), vol. 11, no. 3, pp. 93–95.

Machine Shops. Design, Fabrication and Erection of Small, All-Welded Machine Shop, C. Helsby. Structural Engr. (New Series) (May 1934), vol. 12, no. 5, pp. 263-266 and 268–269.

Pipe, Brass. Welding of Commercial Yellow Brass Pipe, A. R. Lytle and T. W. Green. Welding (Mar. 1934), vol. 5, no. 3, pp. 115–118.

Pipe, Steel. Pipe from Hot Skelp, J. B. Nealey. Wire & Wire Products (Jan. 1934), vol. 9, no. 1, pp. 7–9. Production methods used in plant of Pittsburgh Tube Co., Monaca, Pa. for manufacture of seam-welded steel pipe from hot skelp, using gas-fired furnaces.

Railroad Repair Shops. Profitable Scrapping of Locomotives and Cars, A. L. Prentice. Welding (Feb. 1934), vol. 5, no. 2, pp. 55–58.

Rails. Arc-Welding in Railroad Maintenance, A. M. Candy Ry. Eng. & Maintenance (May 1934), vol. 30, no. 5, pp. 275–277.

Roofs. Novel Welded Frames Used in Monitor Roof Construction. Eng. News-Rec. (May 3, 1934), vol. 112, no. 18, p. 557. Details of special monitor roof construction on new Ford exhibit building at Century of Progress at Chicago.

Shipbuilding. Further Tests and Result of Experiments on Electrically Welded Joints in Ship Construction. B. P. Haigh. Shipbldr. & Mar. Engine-Bldr. (Apr. 1934 Annual Int. No.), vol. 41, no. 290, pp. 222–224; see also Shipbldg. & Shipg. Rec. (Mar. 29, 1934), vol. 43, no. 13, pp. 340–342.

Shipbuilding. Welded Joints in Ship Construction, B. P. Haigh. Engineer (Apr. 6, 1934), vol. 157, no. 4082, pp. 351–352.

Shipbuilding. All-Welded 1620-Ton Ship, N. M. Hunter. Welding (Mar. 1934), vol. 5, no. 3, pp. 103–106; and (Apr.), no. 4, pp. 147–150.

Shipbuilding. Electric-Welded Ship, *"Peter G. Campbell,"* N. M. Hunter. Shipbldr. & Mar. Engine-Bldr. (Apr. 1934 Annual Int. No.), vol. 41, no. 290, pp. 219–222.

Steel Castings. Relationship of Welding Art to Steel Casting, R. A. Bull. Steel (Apr. 30, 1934), vol. 94, no. 18, pp. 30–32. Use of welding to join steel castings to wrought steel parts.

Steel Castings. Welded Rolled Steel Products, F. L. Lindemuth. Iron & Steel Engr. (Apr. 1934), vol. 11, no. 4, pp. 166–168.

Steel Testing. Development of Slip Lines and Fatigue Cracks under Repeated Stresses in Low- and High-Carbon Steels Welded by Butt-Welding (Flash Weld), T. Ver. Iron & Steel Inst.—Carnegie Scholarship Memoirs (1933), vol. 22, pp. 135–156.

Strength. What Makes Steel Hold Together, C. J. Holslag. Welding (Mar. 1934), vol. 5, no. 3, pp. 107–108.

Structural Steel. Application of Correct Design, Good Welding and Field Testing to Structural Work, R. S. Hale. Welding Engr. (Jan. 1934), vol. 19, no. 1, pp. 21–23.

Structural Steel. Lowering Welding Costs by Careful Selection of Steels, W. E. Stine. Metals & Alloys (Apr. 1934), vol. 5, no. 4, pp. 74–76.

Structural Steel. Welding's Challenge to Steel, E. Chapman. Iron Age (May 24, 1934), vol. 133, no. 21, pp. 21–22; see also Steel (May 28, 1934), vol. 94, no. 22, p. 34.

Structural Steel. Welding of High-Tensile Structural Steels. Metallurgist (Supp. to Engineer) (Apr. 27, 1934), p. 128.

Testing. Non-Destructive Methods of Testing Welds, J. W. Donaldson. Iron & Coal Trades Rev. (Mar. 23, 1934), vol. 128, no. 3447, pp. 498–499.

Testing. Corrosion Tests on Weld Deposits, F. R. Hensel and C. S. Williams. Metals & Alloys (Jan. 1934), vol. 5, no. 1, pp. 11–16.

Testing. Using Tests to Determine Correct Set-Up and Procedure for Welding, J. Thom. Welding Engr. (Mar. 1934), vol. 19, no. 3, pp. 24–26.

Training. Selecting and Training Your Welders, J. Zink. Industry & Welding (Feb. 1934), vol. 4, no. 2, pp. 10–12 and 30–32.

Water Pipe-Lines. Big Pipe-Line Arc-Welded on Steep Slopes. Construction Methods (Mar. 1934), vol. 16, no. 3, pp. 26–28.

Water Tanks. Milwaukee's Six-Million Gallon Welded Tank. Boiler Maker & Plate Fabricator (Apr. 1934), vol. 34, no. 4, pp. 109–110.

Wrought Iron. Methods Developed for Best Results in Welding Wrought Iron. Boiler Maker & Plate Fabricator (Mar. 1934), vol. 34, no. 3, pp. 62–64.

BOOKS

"Storungen beim Betrieb von Azetylen-appartan und ihre Beseitigung." This book deals with the troubles that may arise in the operation of acetylene generators with suggested remedies. The first part of the book outlines the features of an acetylene generator and the different types available for various purposes. Illustrations are given of the various types of generators manufactured in Germany. There is some matter dealing with the water seals commonly employed with acetylene generators.

SOCIETY AND RELATED ACTIVITIES

Fall Meeting

The Fall Meeting of the AMERICAN WELDING SOCIETY will be held during the week of October 1st in conjunction with the National Metal Congress in New York. A number of national engineering societies interested in metals are planning to hold their conventions at the same time.

The Exposition space originally set aside has already been sold and it has been necessary to add additional space. The technical sessions of the Society will feature research, design, construction, maintenance, training of welders and economics of welding. Some nationally-known experts in the welding field have agreed to prepare papers for the occasion. This will probably be the largest Fall Meeting and Exposition ever held in the welding field.

The Exposition will be held at the Port of Authority Building, 8th Ave. & 15th Street, New York; and the technical sessions of the Society will be held at the Hotel New Yorker, 8th Avenue & 34th Street, New York. Reservations for space should be made at an early date. Tentative program of the Society will be printed in an early issue.

Tentative Specifications for Steel

The A. S. T. M. has notified the Society that they have recently accepted for publication as tentative the following specifications for steel:

Tentative Specifications for High Tensile Strength
Carbon Steel Plates for Pressure Vessels (Plates 2 In. and Under in Thickness) (A 149-33 T)
Tentative Specifications for High Tensile Strength
Carbon Steel Plates for Fusion-Welded Pressure Vessels (Plates over 2 In. Up to and Including 4 In. in Thickness) (A 150-33 T)

The publishing of these proposed standards is to give the industry and others interested an opportunity to comment and submit criticism for the purpose of developing, when finally adopted, a standard which would be entirely adequate and satisfactory. Members of the Society interested are urged to secure copies of these specifications and comment directly to Mr. R. E. Hess, Assistant Secretary, American Society for Testing Materials, 260 South Broad Street, Philadelphia, Pa., with copy for the Society's files.

Metals & Alloys

Recently the Executive Committee has made arrangements with *Metals & Alloys* so that members of the Society may subscribe to this journal at a special price of $1.50, which is just half of the regular subscription price. This publication is one of the outstanding metallurgical publications in this country and has an excellent abstract service. Through this arrangement members of the Society interested will save a dollar and a half per year.

Standards

The AMERICAN WELDING SOCIETY has available approved American Standards Association Standards for electric welding apparatus and resistance welding apparatus. These Standards were prepared in cooperation with the AMERICAN WELDING SOCIETY. This Society is able to offer these to its membership at a special price of 25c per copy. These Standards have been endorsed by the AMERICAN WELDING SOCIETY.

Obituary

The Society has learned with regret of the death of Allison Wing Slocum, head of the Department of Physics at the University of Vermont, on December 15th. Professor Slocum was born April 22, 1866. He received his Bachelor's and Master's degree from Haverford. He was the Tyndal scholar at Harvard, 1890–1891, and Morgan scholar at the University of Berlin, 1891–1892. He joined the University of Vermont as professor of physics in September 1894.

During one of his sabbatical years he studied at Cambridge University under the famous English physicist, Sir J. J. Thompson.

As a scholar Professor Slocum was characterized by his absorption in his chosen subject. A retentive memory cherished all that his keenly critical intelligence found significant in his extensive reading of scientific literature—his powers of analysis enabling him to distinguish with surprising acumen the true from the false.

Professor Slocum married Mary Whiting Bowers in June 1900. He is survived by his wife and two sons, Edward Bowers Slocum and Allison Wing Slocum, by a brother, Edward B. Slocum of Everett, Mass. and by a sister, Mrs. George Hambly, of Tiverton, R. I.

Some of the older members of the Society will recall Professor Slocum as chairman of a subcommittee on a study of the physics of the arc in arc welding during the war when the Welding Research Committee was affiliated with the Emergency Fleet Corporation and the National Council of Defense. Professor Slocum continued to assist the American Bureau of Welding in similar investigations during the period immediately after the war.

Mr. R. K. Randall, President of the Cleveland School of Welding, Inc., died on April 24th.

Mr. Randall was a moving factor in the training of welders in the Cleveland district for the past twelve years. Before becoming identified with The Cleveland School of Welding, which he helped found, he was the Welding Instructor and later Director of the Trade School of the Y. M. C. A. of Cleveland, Ohio. Mr. Randall has done much work along training lines with men who have been injured in industry and really made a hobby in trying to do good for crippled and disabled men. Mr. Randall was born in Quincy, Mass., in 1889 and prior to coming to Cleveland had followed the welding trade in the shipyards all along the Atlantic Coast. He was one of the founders of the Cleveland Section of the AMERICAN WELDING SOCIETY and served as its chairman as well as Secretary for many years.

At a meeting of the Executive Committee of our Society held on May 22, 1934, the following resolution was adopted:

WHEREAS, The AMERICAN WELDING SOCIETY has learned with profound sorrow of the passing of Reginald K. Randall,

WHEREAS, In the death of Reginald K. Randall the Cleveland Section of the AMERICAN WELDING SOCIETY has lost a valuable member, a pioneer in the art of welding, a man of vision and enthusiasm, a business associate of integrity and honor, a loyal co-worker for the advancement of the welding industry, a helpful and intelligent counsellor and a man whose sterling character will long be remembered by those whose good fortune it was to know him; therefore be it

Resolved, That the AMERICAN WELDING SOCIETY hereby expresses the deep regret of its members in his death, and that the Society honors the memory of Mr. Randall and expresses the deep sorrow for his loss by incorporating this Resolution in the records of the Society and sending copies to his bereaved family and business associates as evidence of its compassion.

June 6, 1934 D. S. JACOBUS, *President*

Membership

A successful drive recently conducted for new members was unusually successful, and the Membership Committee desires to thank those members who cooperated in this drive.

The success of this drive has led the Board of Directors to request the Membership Committee to initiate additional drives during the summer. Every member of the Society who was unable to do his bit in connection with the other drive, is urged by the Membership Committee to participate in this one. The Committee needs more than anything else, lists of names of real prospects to whom can be indicated the value and advantages of membership in the Society.

Membership Certificate

On recommendation of the Membership Committee, the Executive Committee recently authorized the preparation of a Membership Certificate. The Membership Committee had in mind that if such a Certificate was hung in the office of our prominent members it might help to make the Society better known. The Certificate will be engraved on white imitation parchment vellum, size 9 in. x 12 in. suitable for framing. The name and grade of membership will be engrossed and the Certificate will be signed by the President and Secretary.

The Society would appreciate the prompt cooperation of all of the prominent members by obtaining one of these Certificates at once. (Price $1.00.)

Year Book

The AMERICAN WELDING SOCIETY will publish as its August issue a Year Book of the Society. This book will contain, among other things, a complete description of the Society activities, its aims and purposes, reports of important standing committees, reports of the activities of the research department (American Bureau of Welding), by-laws of the Society and the Bureau, an alphabetical and geographical list of the Sustaining Companies, and an advertising section.

Prospective new members are urged to join at once in order that their names might be included in the Year Book. Delinquent members are requested to make payment of their dues at an early date.

Welding Books

The AMERICAN WELDING SOCIETY has made arrangements with various publishing firms to furnish members of the Society with any books on welding at the lowest prevailing prices. Orders may be placed by writing to the Secretary. Some of the books that have recently been placed on the list are:

"Arc Welding Steel Frame Structures," by G. D. Fish. Price, $5.00.

"Designing for Arc Welding," by A. F. Davis. Price, $2.50.

"Arc Welding Handbook," by C. J. Holslag. Price, $2.00.

"Oxy-Acetylene Welders' Handbook," by Welding Engineer Pub. Co. Price, $3.00.

"Manual of Arc Welding," by E. H. Hubert. Price, $2.00.

"Procedure Handbook of Arc Welding Design & Practice," by Lincoln Electric Company. Price, $1.50.

United States Civil Service Examination

The United States Civil Service Commission announces the following-named open competitive examination:

Junior Patent Examiner

Applications for the position of junior patent examiner will be accepted by the U. S. Civil Service Commission, Washington, D. C., until and including June 29, 1934.

The entrance salary is $2000 a year, subject to a deduction of not to exceed 5 per cent during the fiscal year ending June 30, 1935, as a measure of economy, and also to a deduction of 3½ per cent toward a retirement annuity.

A requirement for entrance is that applicants show that they have been graduated with a bachelor's degree from a college or university of recognized standing upon the completion of a full 4 years' course, majoring in engineering; except that it is provided that senior students who are otherwise qualified will be admitted under certain specified conditions.

Full information may be obtained from the Secretary of the United States Civil Service Board of Examiners at the postoffice or custom-house in any city, or from the United States Civil Service Commission, Washington, D. C.

SECTION ACTIVITIES

BOSTON

The Annual Meeting and election of officers of the Boston Section was held on April 13th, and the following were elected:

Chairman—L. F. Jackson
Vice-Chairman—A. S. Coombs
Secretary-Treasurer—H. D. Large

Directors—J. N. Harkins, C. W. Babcock, H. P. Peabody, H. N. Ewertz and W. B. Parker
Trustee—A. L. Coombs
Director of the A. W. S.—H. P. Peabody
New and Delinquent Members—H. N. Ewertz, Chairman

Over 400 attended the meeting held on Friday, May 4th at the Massachusetts Institute of Technology. The meeting was a joint meeting of the Boston Section and the Engineering Societies of Boston. "Boulder Dam" was shown in five reels of film and in many lantern slides. The speakers were Mr. P. C. Idell and Mr. H. R. Karcher, who are associated with the Babcock and Wilcox Company.

Friday, June 1st, was the last meeting until September, and was held at the United States Navy Yard, Charlestown, Mass., as a Joint session with the Boston Chapter, American Society of Metals. Following is the program:

2:00 P.M.—Afternoon Session—Tour of the Yard, Visiting Machine Shop, Foundry Shipfitters' Shop and Forge Plant—demonstration of the manufacture of "Dielock" chain—Boat Shop Ropewalk, Dry Docks where Destroyers *MacDonough* and *Monaghan* are being constructed, and the U. S. Frigate *Constitution*.

6:30 P.M.—Dinner.

8:00 P.M.—Evening Session—in Motion Picture Auditorium. Speakers: Admiral Hough—"Welcome to the Navy Yard." Captain Gay—"Peace-Time Activities of the Navy." Lieutenant Dunning—"Welding Sequence Applied to the Building of Destroyer *351*—U. S. Navy."

This meeting was arranged through the courtesy of Captain R. P. Schlabach, who introduced the speakers.

CHICAGO

The regular monthly meeting of the Chicago Section was held on May 18th at 6:00 P.M. in the Bismarck Hotel. Mr. Robert W. Holt of the Chicago Steel & Wire Company showed black and white pictures of the "arc" as used in welding, and also pictures in natural colors of the arc and weld puddle.

The showing of these moving pictures was preceded by the Annual business meeting and dinner.

DETROIT

Annual meeting of the Detroit Section was held on Thursday, April 19th at Detroit Engineering Society. Election of officers was held and the following unanimously elected for the year: Chairman—R. P. Bailey, Vice-Chairman—W. M. Hayes, Secretary-Treasurer—J. Matte, Jr., Executive Committee for 1934–1936—W. H. Simmons, P. W. Fassler.

NEW YORK

Meeting of the Executive Committee of the New York Section was held on May 8th. Suggestions for subjects of meetings of the Section during the coming season were discussed. For the first meeting of the season, it was voted that it be devoted to a Symposium on Copper and Brass.

Plans for an inspection trip to the General Electric plant at Schenectady, N. Y., were discussed. It was voted that a questionnaire be sent out to the Section membership asking how many would desire to make this trip.

The following Officers and Executive Committee of the New York Section were elected:

Chairman—S. S. Scott
1st Vice-Chairman—P. W. Swain
2nd Vice-Chairman—G. D. Fish
Secretary-Treasurer—A. F. Keogh

Executive Committee
For three years

C. W. Bryan, Jr.	Chas. Kandel
H. H. Moss	G. Van Alstyne

For two years

J. B. Tinnon	R. W. Boggs
F. Eder	M. Male

For one year

G. N. Bull	J. L. Edwards
S. L. Jacobson	E. Vom Steeg

Representative on National Board of Directors
J. B Tinnon